ELECTRO-METALLURGY

PRACTICALLY TREATED

BY

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LECTURER ON ELECTRO-METALLURGY, ETC.; FORMERLY ONE OF THE EDITORS OF "THE CHEMIST;" ETC.

Eighth Edition, Revised

WITH ADDITIONAL MATTER AND ILLUSTRATIONS, INCLUDING THE MOST RECENT PROCESSES

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PREFACE TO THE EIGHTH EDITION.

THE present volume has been carefully revised and extended, and much additional practical information given, which it is hoped will be found acceptable; at the same time it has been deemed necessary to remodel the work to some extent, by subdividing it into two parts—a modification which will doubtless meet with approval.

Amongst the additions will be found a description

of an interesting method of increasing the conductivity of nickel solutions, communicated by M. Desmur to the Author, which will, no doubt, be read with much interest by practical nickel-platers, who know what an indifferent conductor of electricity the nickel solution is.

OLD CHARLTON, KENT.
September, 1882.

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ELECTRO-METALLURGY.

PART I.

PRACTICAL PROCESSES.

INTRODUCTION.

From a simple art almost accidentally discovered, the electro-deposition of metals has become a most extensive industry in this and other countries. In the earliest stage of the art, electrotyping was practised as a pleasing scientific recreation by the rising generation of intelligent youth, who delighted to amuse their friends and themselves by exhibiting the wonderful results which could be obtained, at a trifling cost, by means of a small galvanic arrangement called the "single-cell process." How eagerly the eye used to watch the progress of the beautiful deposit of metallic copper upon the plumbagoed impression of some favourite seal! And how delighted was the student when, on removing the metallic deposit from the sealing-wax impression, he discovered a perfect image of the original, as capable of giving a sharp and delicate impression as the original itself!

This great discovery was made in this country by Mr. C. J. Jordan, of London, and Mr. T. Spencer, of Liverpool, and in Russia by Professor Jacobi, nearly at the same time; so that the credit of the

discovery is equally due to each of them. But, as is frequently the case, it devolved upon others to turn the invention to great practical account, and as a matter of course, to a remunerative one also.

So great was the interest felt in this country—nay, almost all over the civilised world, when this beautiful discovery was made known, that persons of every grade in life devoted their attention to it. The student, the mechanic, the artist, the nobleman and the chemist, with equal zeal, though with different views, deposited copper from its solution by electro-chemical agency. Every one had his set of electrotyping apparatus, and his bath of sulphate of copper. Even among the fair sex would be found many a skilful manipulator, and in such hands, how could the art fail to give beautiful results! Everywhere this art was in vogue, and whilst it was being studied as an amusement by some, others were turning their attention to its commercial value, with a view to making it subservient to the useful purposes of life. So that in a very short time this country was well stocked with a new class of competitors—electrotypists, electro-gilders, and platers. Since then, electro-brassing, and more recently nickel plating have added to the list.

Upwards of forty years having passed away since the introduction of the electro-metallurgical art, it is not to be wondered at that it has ceased to enjoy the popularity which at one time, as we have said, placed it in the hands of all as a fashionable recreation. The interest which attaches to the art, however, is sure *to win for* it devotees in succeeding generations, who *in their turn will* doubtless with equal interest

seek to know the uses of the electric current in the deposition of metals upon each other. To aid this class of rising experimentalists, is now our pleasing task.

To those who desire to practise the arts of electro-gilding, plating, &c., with a view to applying the same to commercial purposes, it is hoped that the present work will prove of service, since it is the intention of the author to make it entirely of a practical nature, and as free as possible from technical expressions.

Having had considerable experience in the electro-deposition of metals on a very extensive scale, dating from the initiation of the art, during which period many thousands of ounces of the precious metals have been deposited by me; and having paid great attention to the subject of electro-deposition generally, I have naturally met with many difficulties which careful experiment and perseverance have overcome. Therefore, in laying before my readers the result of my own practical experience, it is with the hope that they may prove useful to those who pursue the study of electro-deposition, either for instructive amusement or profit.

It has been my aim to furnish the reader with such processes as have been found most successful, whilst new processes which have been introduced from time to time have been also considered, so as to render the work as far as possible a complete book of reference.

The reader's attention is specially directed to the Practical Notes (p. 125), wherein, it is hoped, he will find much useful practical information.

To render myself as intelligible to the working electro-plater and the amateur, as to the more scientific reader, I will fully explain the meaning of any

technical terms which may necessarily occur in the way, so that he may not fall into errors which too frequently—more especially in a chemical art—retard the progress of study.

In depositing metals from their solutions, many forms of galvanic battery are employed. Among those most commonly known are Daniell's, Smee's, Wollaston's and Bunsen's. The first of these, Daniell's battery, has been almost abandoned, owing to the trouble which it involves to keep it in good working order. The second, Smee's battery, although far from economical, and somewhat uncertain in its action, is still employed by some, owing to the great *intensity* of the current which it produces (a quality of but little service to the electro-plater when the *quantity* is deficient, as we will presently explain). The third, Wollaston's battery, by far superior to the latter for electro-metallurgical purposes, as it yields a great *quantity* of electricity of moderate tension, is also frequently employed, or rather modifications of the same arrangement, which are fitted up with but little trouble and expense ; whilst Bunsen's battery is only capable of being employed in depositing those metals which require a current of great intensity, as well as quantity: for instance, brass, bronze, German silver, zinc, nickel, and a few other metals.

It must be borne in mind, that in order to ensure a perfectly smooth, equal, and *reguline* deposit on a metallic surface, the battery to be employed should yield a *considerable quantity of electricity of sufficient intensity to work with activity* and *uniformity*. A battery constructed with a large surface of positive and negative elements—as zinc and copper for instance—will yield

a current of such feeble intensity in proportion to that quantity, that, when employed for the purposes of electro-deposition, the deposit takes place very slowly; whilst a battery consisting of a great number of small plates or cells, alternately arranged, would not only deposit the metal in a granular or pulverulent form, but would actually decompose the solution itself. Consequently, in order to obtain a good reguline deposit of any metal, a battery should be employed whose positive and negative elements are in such relative proportion as to yield a current of quantity electricity possessing sufficient intensity to enable that quantity to work well.

A form of battery which I have found most constant and certain in its action, I will describe further on, as also one which is much used in extensive operations where great power is required to deposit large quantities of metal, as in the processes of electrotyping and electro-plating.

Faraday employs the terms *anode, anelectrode,* or *positive electrode,* for the positive pole of the battery—*i.e.,* the wire which proceeds from the copper element in a battery; and *cathode, cathelectrode,* or *negative electrode,* for the negative pole—that which procceds from the zinc element. Professor Daniell, however, objecting to the terms *anode* and *cathode,* proposed the adoption of *zincode* and *platinode,* to distinguish the positive and negative poles; but as the elements of a battery are not necessarily composed of zinc or platinum, and as, independently of the great weight which must always attach to any system propounded by Mr. Faraday, it would sound rather unmusical to speak of leadodes, *carbonodes,* or *copperodes,* when describing the poles o

a battery with an element of lead, carbon, or copper, I prefer adopting Faraday's nomenclature.

The electricity generated in a cell passes from the zinc to the copper element of the battery, and from thence it proceeds along the wire issuing from the copper, traverses the solution, and returns to the cell through the wire which is attached to the zinc element, and so on. The zinc is the *positive* and the copper the *negative* element, but the end of the wire attached to zinc becomes the *negative pole*, whilst that proceeding from the copper becomes the *positive pole*.

The *anode*, or positive pole, is that wire which is attached to the copper cylinder or plate of a battery; and to this wire or pole is suspended, in close contact, the sheet or plate of metal which is destined to re-supply the solution with the amount of metal which it loses by the deposition which takes place on the cathode or article to be coated.

The *cathode*, or negative pole, is the wire which issues from the zinc plate or bar of a battery, and it is this wire or pole, or any metallic surface which may be attached to it, which receives the deposit in the bath.

Professor Faraday denominates the solution, whether it be of silver, gold, copper, or any other metal from which a deposit is to be obtained, the *electrolyte*.

Quantity electricity, as I have already observed, is that kind of current which is produced when the battery is formed of large surfaces of the metallic element; it is this species of electricity which is most useful for the purposes of electro-deposition.

"Experience proves that, in general, the adherence of the oxides and of the metals gold, silver, copper, *and lead on metals*, is greater as the intensity of the

current is less, within certain well-known limits; and as the solution is less concentrated." *

Intensity may be given to the quantity already existing in a series of cells or plates, by increasing their number; thus, by attaching the wire proceeding from the positive pole of one cell to the negative pole of another, and so on, until a compound battery is formed of alternate pairs. A battery thus constructed is well adapted to the purposes of electro-chemical decomposition, or *electrolisation*, the electric light, the giving of shocks, and other powerful effects of electricity; but, unless carefully applied, it would be highly injurious if devoted to electro-metallurgical operations.

An intensity current seldom lasts longer than a few hours, unless fresh exciting fluids be applied to the elements with which it is produced; but a quantity current may continue to be developed from a constant battery for months. I have known a constant battery continue in action for twelve months *without any addition whatever*, at the end of which period it still gave considerable evidences of electrical action.

The Battery.—A useful battery for small operations is represented at Fig. 1. It consists of a cylindrical stone jar capable of holding about four gallons: inside this jar is fitted a cylinder of sheet copper, C, which may be $\frac{1}{32}$nd of an inch in thickness. A strip of the copper cylinder, B, about half an inch broad, is cut off

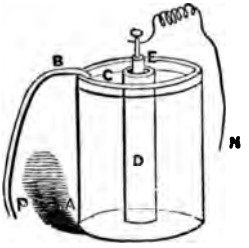


Fig. 1.

* *Becquerel*, "The Chemist," 1843, vol. iv. p. 400.

to within one inch, to form the positive electrode; the object in doing this is to ensure a perfect connection without the trouble of soldering.

A circular piece of wood forms a covering to the jar; in the centre of which a hole about three inches in diameter is cut, so as to admit a porous cell to pass through it. The porous cell should be at least two inches higher than the stone jar. A zinc bar, E, (Fig. 2) is cast with a long and tolerably thick copper wire in it, one end of which has been previously coiled into a helix, so as to form a spring, to prevent the wire from breaking off at its junction with the zinc bar. The porous cell is to be nearly filled with a concentrated solution of common salt, to which a few drops of hydrochloric acid may be added, or if the zinc bar be amalgamated (see page 140) dilute sulphuric acid must be used as the exciting fluid. The outer cell or jar is to be nearly filled with water acidulated with sulphuric acid (about one part acid to twenty parts water), to which about one ounce of nitric acid may be added. This battery will be found useful for small gilding and plating operations, and for electrotyping on a small scale. P and N (Fig. 1) signify positive and negative.

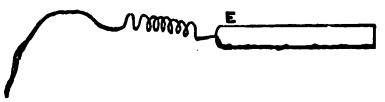


Fig. 2.

A series of these cells, arranged for quantity, as described at page 141, will form a very useful compound battery for electrotyping, silvering, or gilding.

In the above form of battery several advantages present themselves; its action is constant, there is but little local action, and consequently but little waste;

its current is regular, and it is very economical in its construction and inexpensive in use.

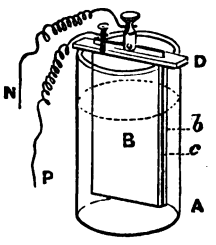
A compound battery thus constructed will give most powerful effects when a number of cells are used, and it will continue to give these effects for a greater length of time than any battery with which I am acquainted.

In a single cell of this battery, a considerable quantity of electricity is disengaged, of sufficient intensity for small operations, such as gilding and so forth. When it is desired to deposit a large quantity of metal in a given time, several of these cells alternated, that is, having the zinc wire of one cell united to the copper cylinder of the next, and so on, may be employed, by which arrangement a vast amount of metal may be deposited in a short time, when the solution is in good working condition. But it is preferable to unite all the copper wires and the zinc wires, by which arrangement the intensity is not increased.

In working with a Smee's battery in the large way, the rapid consumption of the zinc plates, the furious local action and offensive evolution of hydrogen gas which it is susceptible of, and the trouble and expense of amalgamating the plates, are among the many disadvantages which this battery exhibits to the practical electro-metallurgist; added to which, the current which proceeds from it is far too intense and fluctuating to enable us to obtain a smooth and reguline deposit. But for many experimental purposes this is one of the most convenient and ingenious batteries known, and Mr. Smee deserves the highest credit for its introduction, as its great popularity will testify.

Wollaston's battery, were it not for the trouble and

difficulty of replacing the zinc plates when they are consumed, and the constant application of exciting material which it requires, would be admirably suited to electro-metallurgical operations. A useful modification of Wollaston's battery, however, is now much in use. It consists of a cylindrical stone jar, A, capable of holding about ten gallons; two pieces of sheet copper are fixed upon a wooden support, D. A plate of amalgamated zinc, *c*, is placed in a groove cut in the wooden bar or support between the copper plates. A binding screw is soldered to the copper plates, B *b*, which are united by strips of copper, soldered to them, and a binding screw is to be fastened to the zinc plate. The jar is to be filled with sulphuric acid one part, water fifteen parts. The zinc must be well amalgamated.



Since the introduction of the dynamo-electric machine (see page 87), the battery, for large operations, has to a great extent been superseded; and there is no doubt that ere long dynamo-electricity will be the chief if not the only source from which the current will be obtained for extensive electro-deposition purposes. Those defects which the earlier magneto-electric machines presented have been entirely overcome, and the dynamo-electric machine may be said to be, when properly managed and carefully used, by far the most serviceable machine which the electro-plater has yet obtained. These machines are made for intensity or quantity, so that in every respect they represent the best batteries ordinarily used for the various purposes *of the electro-metallurgist.*

There are other circumstances besides the power of the battery which affect the nature of the deposit, or the speed with which it is obtained. The solution, or *electrolyte,* may be what is termed a *good* or a *bad* conductor, according to the amount of metal or the proportion of the solvent existing in it; or the extent of surface of anode or positive electrode immersed in the solution while deposition is taking place. If the solution be poor in metal, &c., and the surface of anode exposed to the article which is to receive the deposit be smaller than is required, the operation will go on slowly; whilst, on the other hand, a superabundance of metal and the solvent being in the solution, and the surface of anode exposed being considerable, the deposit may take place so rapidly that it will be thrown off the cathode, or article coated, in the form of a powder, or myriads of minute granules.

Again, the speed with which the deposit is obtained depends upon the temperature of the solution. When the solution is raised to the temperature of 60° C. (140° F.), deposition takes place very rapidly; indeed, in order to bring the solution to a strength which will enable you to use it hot without fear of granular deposition and other imperfections, nearly 75 per cent. of water must be added to it, and the surface of anode immersed be diminished.

In excessively cold weather, I have frequently found a silver solution covered with ice of considerable thickness, and consequently the deposition has taken place more slowly than was desired. In this state the deposit was much harder, and less inclined to be "rough," than when the solution was of a higher temperature. I would at all times prefer working the silver solution

at as low a temperature as possible, as I think the deposit, under such circumstances, is in many respects of a superior quality.

Motion will also materially affect electro-deposition. If the solution be too strong; the surface of the anode exposed be excessive; the solution be of too high a temperature; the battery too powerful, or if any one of these circumstances give rise to a pulverulent or granular deposit, or cause the metal to "strip," or peel off the article on which it is deposited, by keeping the negative electrode and the article attached to it in constant and rapid motion until the required coating is obtained, a perfectly smooth, uniform, and tenacious deposit will be secured, though the circumstances referred to be ever so unfavourable. For example, if you attach an article to the negative electrode, and place it in the gilding bath, and if, after a few seconds, you observe that the gold is deposited of a dull brown colour, by very briskly agitating the article in the solution it will instantly become bright and of a good fine-gold colour.

There are circumstances under which no deposition whatever will take place. The following occurrence will illustrate a curious phenomenon which occurred to my brother and myself some years ago. We had been plating large quantities of spoons and forks in an apartment for several years, during which time our operations had been most highly successful, and we had been much praised for the quality of our deposit. One day my brother found, to his great annoyance, that no deposit whatever would take place on any article immersed in the solution. Something was wrong. Entirely new batteries were applied, but with no better success;

fresh solutions were made, but still no deposition of silver took place. The batteries and solutions were next insulated from contact with the ground, as we thought it probable the current was being conducted away somehow or other, and yet no favourable change occurred. Thus matters went on for nearly a fortnight; all hands were idle; the workpeople enjoyed a kind of extended Easter holiday, or were hoping something favourable would "turn up" from day to day. At last, having tried every expedient that suggested itself to our almost distracted senses, it occurred to me that if the solutions and batteries were removed to *another apartment* we might meet with better success. The experiment was tried and it succeeded. Once more we could observe the beautiful deposit of silver upon the metallic surfaces, and all went on well.

Whatever may have been the cause of this inaction, some time afterwards the operations were carried on in the same apartment with perfect facility.

In practising the art of electro-deposition, it is necessary to observe the strictest cleanliness, and to be careful not to allow the solutions in any way to be mixed with each other.

It will be necessary to have various kinds of solutions, of certain strengths, in order to deposit one metal upon another with tenacity and firmness. The same solution will not do well for all metals. It is the neglect of this fact which causes many failures, and many solutions to be spoilt. A solution which will allow a good deposit of silver to take place on copper or brass, will not be applicable to steel, as the silver would instantly blister or peel off the latter. Again, a solution which would deposit a faultless coating c

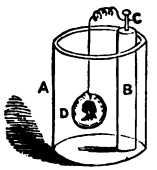
copper on iron would deposit a very bad coating on zinc.

To those who are unacquainted with science, I may observe that they need not be deterred from the study of these arts by any apparent abstruseness which may, at first sight, surround it. In the present portion of this work I have been under the necessity of entering chiefly into scientific considerations: but will now commence the details of the various processes of electro-deposition, which I will endeavour to render as simple as possible, in order that they may be fully understood, even by those who now enter upon the study of this subject for the first time.

ELECTRO-DEPOSITION OF COPPER.

Many valuable additions were made by the various manipulators in the beautiful art of electrotyping, one of the first of which was Mr. Murray's application of plumbago as a coating for surfaces which are non-conductors of electricity.

Electrotypes were originally produced in a cell which formed at the same time the battery and the decomposition bath, thus :—A jar A was charged with a concentrated solution of sulphate of copper ("blue stone" or "blue vitriol"). A porous cell B, a bladder, or a glass tube having one end covered with a piece of bladder, was placed in this solution, and a piece of zinc with a copper wire c attached was placed in this cell, which was then filled with dilute sulphuric acid or salt and water the object to be copied, being previously prepared, was suspended to the end of this wire D and immersed in the



copper solution. This was termed the "single cell" arrangement; it is even now occasionally used by electro-metallurgists in some of their operations.

Subsequently, experimentalists applied a separate battery for the purpose of depositing copper from its solution, and it was found that operations on a large scale could thus be carried on with considerable speed and other advantages. Mr. Mason has the credit of being the first who applied a separate battery to the production of electrotypes.

When a separate battery is used, it is necessary to attach the mould to be copied to the negative electrode, —the wire proceeding from the zinc of the battery, and a piece of sheet copper is attached to the positive electrode—the wire issuing from the copper of the battery. In this arrangement the object to receive the deposit constitutes the *cathode,* and the copper plate the *anode.*

Copper Solutions.—The solution for electrotyping by means of the "single cell" arrangement should be composed of a nearly saturated solution of sulphate of copper, with two ounces of concentrated sulphuric acid added to the gallon of saturated solution; one drachm of arsenious acid (white oxide of arsenic) may be also added to improve the character of the deposit, but this is not indispensable. A little chloride of tin may be substituted for the arsenic.

The sulphate of copper may be dissolved in boiling distilled or rain water, or even common water, and allowed to cool, the sulphuric acid being added when the solution is quite cold.

Sulphate of copper is frequently adulterated with sulphate of iron ("copperas" or "green vitriol"), therefore it is necessary to obtain the article at a

respectable establishment; in fact it is advisable always to procure substances required for experiment, or even for more extensive operations, where their purity can be depended upon. If every one adopted this principle, those who vend impure materials would soon be compelled to follow the example of their more honest competitors, and to sell pure articles, however little in accordance with their wishes.

The solution required for depositing copper with a separate battery is composed of—

Sulphate of copper		1 pound.
Sulphuric acid		1 ,,
Water	(about)	1 gallon.

to which may be added a small quantity of arsenious acid or chloride of tin.

PREPARATION OF MOULDS.

The material of which a mould is composed will depend upon the nature of the model; the same composition will not do well for all purposes.

Moulds from Plaster of Paris Models—may be obtained by any of the following methods:—If the object to be copied be a plaster medallion, for instance, let it be placed in a plate or large saucer, with its face upwards, and pour boiling water all round it until it nearly reaches the upper edge of the cast; allow it to remain in the water until the face of the object assumes a moist, but not wet, appearance; then remove it from the plate and surround it with a rim of card or thick *drawing*-paper, allowing sufficient depth in the rim to *hold a requisite* quantity of the moulding material. *This rim of card may* be conveniently kept in its posi-

tion by sealing-wax. A rim of sheet tin or brass will be found also to answer the purpose very well, but it must be secured to the medallion by means of fine binding wire or a split ring. The medallion must not stand for longer than two or three minutes after it is taken out of the water, before the composition is poured on. It is better to put the rim of card round the cast before immersing it in hot water. The following composition, being melted and at the point of cooling, is then poured into the mould.

White wax	6 ounces.
Spermaceti	1 ,,
Stearine	8 ,,
Carbonate of lead	1 ,,
	16

These compounds should be well melted together, the carbonate of lead being added last, and thoroughly stirred; care must be taken that the heat applied be not sufficient to form air-bubbles. As soon as the composition is poured on the medallion, it is advantageous to quickly stir it with a camel-hair pencil to dissipate any air-bubbles which may have resulted from pouring in the composition too suddenly. Also, the mould thus formed should remain for several hours to become quite cold; the more gradually it cools the better. The rim may now be removed and the mould separated from the medallion. Should there be a tendency for the two surfaces to adhere, the plaster cast may be again placed in boiling water for an instant, when it will come away readily. Sometimes, however, the composition will adhere to the plaster in spite of all precautions, in which *case it is* advisable to force it asunder, taking *care not to injure* the composition mould. If some of

the plaster is found to adhere to the mould, place the latter in luke-warm water for a short time; this will somewhat soften the adherent plaster, and will enable portions of it to be picked off the surface of the mould, and with a very soft brush much more will come away. Should any plaster still obstinately remain adherent, dry the mould and apply with a thin piece of wood a little sulphuric acid to the fragments of plaster remaining, and leave the mould exposed to the air for some time, when the acid will have attracted a certain quantity of moisture from the air, and their united action will cause the gradual dislodgment of the plaster, which may be brushed away with a soft brush and water.

Gutta percha is another excellent substance for making moulds from plaster of Paris models. The gutta percha must be boiled in water for some length of time until it is quite soft. The object to be copied, if a plaster medallion, should have its surface slightly oiled, and then be provided with a rim as before described, and the softened gutta percha, being wiped dry and rolled into the form of a ball, placed in the centre of the model and worked with the hand until every part of the medallion is covered with it, when a smooth piece of wood (previously greased) may be placed over it and pressure applied until the mould is thoroughly set. In about an hour or so it may be removed from the model. It is necessary to bind the rim round the plaster cast *very tightly*, in order to render the object less liable to fracture and to keep the parts well together if an accident does happen; or the *plaster cast may* be imbedded in a little melted wax, *poured on a plate,* previous to the gutta percha being *applied; by this* means the plaster will be quite secured

from fracture. Pressure may be conveniently applied by placing the mould, &c., between two pieces of perfectly flat wood and then screwing them in a vice, taking care that they be properly adjusted so that the pressure may be uniform, or a weight may be placed on the mould, and allowed to remain for half an hour or so.

Moulds in fusible metal may also be obtained from plaster casts. The plaster model should first be well soaked in boiled linseed oil, to which a little "patent dryers" has been added, and allowed to remain for several days before taking the mould, when it will have become exceedingly hard. The mould may then be taken from the plaster cast in the same way as from medals, described further on.

Elastic moulds, as they are termed, may be made from casts in plaster. The composition for this purpose is—

Glue	12 ounces.
Treacle	3 ,,

Soak the glue in sufficient water to render it quite soft. As soon as the glue is quite liquid, add the treacle and mix them well together. The plastic cast must be thoroughly saturated with boiled linseed oil, containing a little "patent dryers," and be laid aside for a day or two, if convenient, to harden before the elastic mould is made from it. This material for moulds is generally applied to objects which are either much "undercut," or are in considerable relief, and from which, consequently, it may be impossible to obtain a perfect copy without this composition is resorted to. The elastic moulds are thus made. If we desire to copy a figure of plaster, after it has been subjected to the linseed oil, &c., let the hollow in the figure be filled up with sand,

and the orifice at its base be well closed with a piece of card or oilskin pasted over it. The figure is now placed perpendicularly in a jar of cylindrical form, and rather deeper than the height of the bust; the jar should be previously well greased. The plaster cast must have an abundance of oil brushed or poured over it before it is placed in the jar, and the composition is poured in until it covers the bust and is an inch or two above it.

After allowing the mould thus formed to remain for a day or so to become thoroughly set, the jar may be turned upside down, and the mould will readily slip out. A very sharp, bright, and thin-bladed knife, is now passed from the top to the bottom of the figure at its back, very cautiously, and the mould may be opened and the plaster model withdrawn. As soon as the model is removed, the mould, being elastic, will close itself. A strip of oiled paper or rag is now carefully wrapped round the mould, in order that it may retain its proper position: it is a good plan, also, to place three or four pieces of wood of equal thicknesses, at equal distances round the mould, secured by a piece of twine; this will protect it from injury. The mould being inverted, is now filled with a mixture of about equal parts of bees'-wax and resin, and a small quantity of plumbago and tallow. The mixture should not be poured in until it is beginning to cool. The whole should be allowed to rest for a few hours until quite cold, when the wooden props and bandages may be removed, the mould reopened, and the composition *figure gently* withdrawn. The mould will do for future *occasions.*

When the mould is made of the wax composition, it

should be treated in the following manner. Bend a piece of stout copper wire in such a way that it may, when slightly heated, be conveniently placed round a portion of the edge of the medallion, to which it will adhere firmly when cold. Then apply, with a soft camel-hair, badger-hair, or other very soft brush, finely powdered plumbago (common blacklead will do) until the whole surface of the mould has acquired a metallic lustre. The brush with which the plumbago is applied should be worked *in circles*, so that every little crevice in the mould may be thoroughly coated; it may be advisable also to plumbago the finger and rub the flat surfaces of the mould with it, in order that they may be uniformly blackleaded.

It is sometimes advantageous to breathe upon the surface of the mould when applying the plumbago; care must be taken that the end of the conducting wire attached to the mould, and that part of the composition near it, receive a good coating of the plumbago to insure a perfect connection between the wire and the plumbagoed surface. The edge of the mould should be scraped round with a knife, in order to remove any superfluous plumbago which may have been communicated by the fingers, or otherwise this part of the mould will receive the deposit, and render it difficult to separate the electrotype from the mould. But care must be taken not to remove the plumbago from the wire and adjacent composition.

The mould is now ready to be placed in the solution bath; if it is desired to obtain a good thick deposit, it may be left in the bath for two or three days or even longer. When the mould has received the required coating, remove it from the bath, detach it from the

conducting wire, and then gradually loosen the electrotype with the point of a penknife. Should there be any copper deposited on the outer edge of the mould, thereby rendering it difficult to separate the one from the other, this may be broken away and the obstacle thus removed. It is advisable, before taking the electrotype from the mould, to cut off the conducting wire as close to the copy as possible, in order to render the detachment more manageable.

As soon as the electrotype is free, it may be heated to cherry redness in a clear fire, or, which is better, by a blast from a blow-pipe, and when thus *annealed* it will be exceedingly tough, and less liable to be broken. When cool, the electrotype should be plunged into cold water acidulated with sulphuric acid, and allowed to remain in it for some minutes, when it may be rinsed and dried, the edges clipped with a pair of jewellers' shears, and filed to the proper form.

The electrotype may now be polished with rottenstone and oil, applied with a rather stiff brush. It may then be washed with boiling water and soap, dried, and, lastly, polished with moistened rouge and a soft brush, the plain surfaces being polished with the second finger and rouge.

Previously to polishing the electrotype, the hollow surface at the back may be filled up with pewter solder and lead, thus:—Dissolve a piece of zinc in hydrochloric acid (muriatic acid) and apply a little of the solution all over the back of the electrotype; cut up some pewter solder into small pieces and place them on the back, put the copy on a piece of charcoal, and apply the blow-pipe flame until the solder has "run" into every *crevice.* Some pieces of lead may now be treated in a

similar way to give additional substance to the electrotype, and it is cheaper than solder. The copy may now be bronzed, plated, or gilt, and mounted on a piece of black velvet, or otherwise disposed of, according to the taste of the electrotypist.

Moulds from Metallic Substances may be obtained by any of the following processes:—Suppose it be a medal which we desire to copy, let a stout piece of copper wire be soldered to the edge or back of the medal, or let a thinner piece of wire be twisted tightly round its edge. Then place the medal, face upwards, in a plate containing a little melted wax, suffering the wax to reach about half way up the edge of the medal, then remove it for a moment, and replace in the wax once more to give an additional coating. Or soften a piece of gutta percha, roll it into a ball, and, having cut a hole of the size of the medal in several pieces of card, or one thick piece of cardboard, place the medal, face downwards, between these holes and press the gutta percha on the back of the medal, and put a weight upon it. It may be advisable to coat the back of the medal with a solution of gutta percha, in order to give the lump applied a greater inclination to adhere, or the medal may be somewhat heated before the gutta percha is applied.

The face of the medal is now to be slightly greased either with olive oil, trotter oil, or melted goose fat. This is best done with a camel-hair pencil or a piece of cotton wool. The superfluous oil is then to be removed from the medal by means of a piece of clean cotton wool or a silk handkerchief. Solutions of wax in alcohol or turpentine have been substituted for oil or grease. The surface of the medal may also be plumbagoed with advantage, in which case the oil may be dispensed

with. The medal is now to be put into the solution bath, and allowed to remain until sufficiently well coated, when it may be removed, washed, and the mould carefully separated from it.

The mould may now, in its turn, be oiled or plumbagoed, and placed in the bath, and a deposit being allowed to take place upon it, the operator will have obtained an exact representative of the original. This may now be treated in the same way as the electrotype from a wax mould.

The next process for obtaining moulds from metals, consists in first oiling or plumbagoing the surface of the medal, then placing a rim of card round its edge, secured by sealing-wax. Some very fine plaster of Paris is now mixed to the consistence of thick cream, and this is carefully poured over the face of the medal with a table-spoon; a camel-hair pencil is now used to stir the plaster on the medal, in order to dissipate any air bubbles which may have been formed when pouring on the plaster. The brush is quickly plunged into water, and the plaster allowed to remain for an hour or so to harden. When the mould is separated from the medal, it should be placed aside to dry as much as possible, and it must be well charged with melted wax before being plumbagoed. A wire may be firmly twisted round it, and the *connection* between the wire and the mould be secured by brushing the plumbago at that part only where the wire is twisted; otherwise, should the whole of the coil of wire be plumbagoed, there may be considerable difficulty in detaching the copy when the *deposit* is obtained. As before, all superfluous plumbago *should be* scraped off the edge of the mould *before immersing* in the bath.

Gutta percha moulds may also be obtained from metallic substances in the same way as from plaster models.

Sealing-wax has also been employed to obtain moulds from metallic surfaces, but it is not so suitable as either gutta percha or the following :—

After a medal has been oiled or plumbagoed as before, and a rim of card bound round its edge, a mould may be made of the wax and stearine composition, which is melted gradually, and when it begins to solidify, it is carefully poured on the surface of the medal, this being held at a slight angle at the time in order to prevent the formation of air bubbles. If the composition is too hot, or if the mould be too quickly removed from the medal, it will surely adhere. The mould should not be removed for several hours. If, however, with all precaution, the mould has an inclination to adhere to the medal, place them for an instant in hot water to expand the medal, when it will separate easily.

Moulds in fusible Metal, prepared by various processes, are also obtained from medals, &c. The fusible alloy may be formed from any of the following formulæ :—

Melt together in a crucible or clean ladle

Bismuth	8 ounces.
Lead	5 ,,
Tin	4 ,,
Antimony	1 ,,
	18 ,,

While these substances are being fused, nearly fill *a cylindrical jar of* considerable depth, with cold water. *Cut some hay or* straw into pieces of about three

inches in length, and place them in the water. Let some person keep this well stirred until the metal is ready to pour. The stirrer is then withdrawn quickly and the melted alloy poured in. This will finely granulate the alloy. The water being now poured off the granulated metal, it may be dried and remelted. By this means the alloy becomes thoroughly well mixed.

Or either of the following mixtures may be treated in the same way.

I.

Bismuth	8 ounces.
Lead	4 „
Tin	4 „
	16 „

II.

Bismuth	8 ounces.
Tin	2 „
Lead	4 „
Cadmium	2 „
	16 „

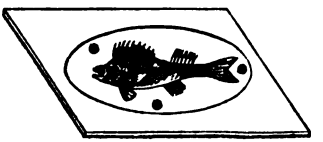
The latter formula is the most fusible of those given, its melting point being 160° Fah., or 52° below the boiling point of water.

When a medal is to be copied by the fusible alloy, it should be placed on a smooth piece of wood, and the edge of the medal traced round with a pencil upon the wood; a hole is now to be cut in the wood, as deep as half the thickness of the edge of the medal, and when this is done the medal is to be placed in this cavity, and made fast to it by means of moist blotting-paper or otherwise. (*See engraving.*) Or the *back of the* medal may be imbedded in a thick paste of

plaster of Paris, up to half the thickness of its edge, and the plaster worked up so as to form a kind of handle for the medal, which should not be greased for this purpose. When the medal is secured by either of the above means, a wooden block is to be obtained, a part of which is to be greased a little, and a quantity of the fused alloy poured quickly on it, and this is to be worked up with a thin piece of wood, or card, into a mass of pasty consistence. If a pellicle appears on the surface it must be quickly removed with the card, and the medal be brought suddenly upon the cooling alloy, where it must be held steadily for a few moments until the alloy has quite *set*.

It is absolutely necessary to act with promptness and expertness, in order to obtain good moulds by means of the fusible alloy.

Moulds from Animal Substances.—Let us presume that the object to be copied is a fish. A quantity of plaster of Paris is mixed into a thickish paste, and poured quickly on a piece of plate-glass or sheet tin, slightly greased, to prevent the adhesion of the plaster; or a sheet of paper, greased on one side, placed on a level surface of wood, will answer this purpose very well. The fish may then be laid on its side upon the plaster, and a little gentle pressure applied until one-half of the fish is imbedded. (See



woodcut.) It is advantageous, sometimes, to brush oil over the fish, previous to placing it in the preparation of plaster. As soon as the adjustment of the fish is complete, it may be allowed to remain until the plaster is thoroughly *set*, but not hard; the fish may then be carefully removed from the mould thus formed, and any "ragged edges" which may appear on the mould, may be smoothed with a penknife. Three holes, of a conical form, and at least half an inch deep, should now be bored in the face of the mould, thus,—one near the middle of the fish's back, another below the head, and a third beneath the tail.

The mould must then be brushed over with soap and water, a very soft brush being applied, and the fish is then carefully replaced in its former position. Then, having made a further quantity of plaster into a *thin* paste, pour it quickly on the fish and mould, taking care that the three holes be filled with the plaster. Should any air-bubbles occur during the pouring on of the plaster, they must be instantly dissipated with a soft brush or thin piece of wood. Having applied sufficient plaster to make a strong mould, let the whole rest until the moulds are quite hard, when they may be separated and the fish withdrawn. The upper mould will have three projections, corresponding to the holes in the lower mould, which will enable the operator to put the moulds together with facility and accuracy.

These moulds may now be placed in an oven until they are quite dry, and should then be put into a shallow vessel, containing melted wax, and allowed to remain therein until they are quite saturated; as soon as the moulds are cool they are ready to receive the *plumbago, or other* conducting medium.

Several holes should then be drilled in the edge of each mould, and a stout copper wire, bent at one end, be inserted in each hole, the terminations of these wires being well bound together, so as to prevent the mould from shifting from the wires. Several pieces of fine wire (jewellers' binding wire will answer this purpose very well) may be twisted round the conducting wire, and their ends be allowed to touch the surface of the mould in several places, in order to aid the deposit, which, when large surfaces are exposed, is apt to take place principally or entirely at the points of the conducting wires. Care must be taken that the portions of the mould to which the wires are attached be well coated with plumbago, and the edges of the mould should be scraped, in order to free them from any plumbago which may have been communicated to them; otherwise, when the deposit is obtained, it may be found difficult to separate the mould from the electrotype.

When the two halves of the fish are thus obtained in electrotype, the extraneous copper should be removed as before directed, and being filed until they will lay close together, the inner edges may be tinned with chloride of zinc and pewter solder, and being brought together, a blowpipe flame will soon complete the union. A perfect representation of the fish is here obtained, which may be either bronzed, plated, or gilt, by any of the processes hereafter to be described.

Moulds from any animal substances may be obtained by the above plan.

In some instances it may be advisable to make a mould of an animal in the elastic material before spoken of, in which case one half of the object may be imbedded in sand, and a cylinder of sheet tin made to

surround the object, and being an inch or two higher it may be stuck in the sand. The elastic material is now to be passed into the cylinder, until it nearly reaches the top; it is allowed to remain until the composition has thoroughly set, when the metal rim may be removed, and the object separated from the mould. The other half of the object may be treated in the same way. The composition of wax and stearine may now be poured into each half of the mould, and plaster moulds may be taken from the wax models thus formed, which, being saturated with melted wax, may be plumbagoed and electrotyped.

Moulds from Vegetable Substances, may be generally taken in the same way as from animals. Leaves, sea-weeds, &c., may be thus copied:—Suppose we take a fern-leaf for example: let the back of the leaf be carefully imbedded in a paste of plaster of Paris, and with a piece of wood, guide the plaster so that it may fill up every crevice that is not to be copied. When the plaster is quite hard, melted wax may be poured over the leaf (which should be dusted over with plumbago previously, to prevent the wax from adhering), and allowed to remain until quite cold. The leaf and plaster should now be separated from the wax mould, which is then ready to receive the plumbago, &c.

Another good plan is, to brush over the back of the leaf with thin plaster, layer after layer, until it has received a good stout coating; this may now be imbedded in sand, and wax poured on as before.

Fern-leaves, sea-weeds, &c., may be imbedded in clay *before the wax is* applied to them.

The elastic moulding will also be found very useful in *copying vegetable* substances.

Gutta percha can seldom be applied with advantage to the copying of delicate objects of vegetable or animal nature, owing to the amount of pressure it requires to obtain an impression.

Having described the various moulding materials employed by electrotypists, we will proceed to the general applications of the art of electrotype.

Articles of glass may be coated with copper, by first covering them with a solution of gutta percha in turpentine or naphtha, or wax dissolved in turpentine; the article is then coated with plumbago, &c., in the usual way. The surface of the glass vessel may be rendered somewhat rough by submitting it to the fumes of hydrofluoric acid, but this is seldom requisite.

In some cases it will be found difficult to apply plumbago to a given surface, in which case the following mixture may be employed:—

Wax or tallow	1 pound.
Spirit of turpentine	1 pint.
India rubber	2 ounces.
Asphalte	1 pound.

Melt the wax or tallow, then dissolve the caoutchouc and asphalte in the turpentine, and add to the wax, stirring them well. Now pour in one pound of the following solution:—

Phosphorus	1 pound.
Bisulphuret of carbon	15 pounds.

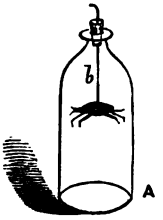
Smaller quantities may be mixed up in the same proportions.

These substances being well blended together, objects to be electrotyped are brushed over with the composition, *or, being attached* to a wire, are dipped into it. *A weak solution of* nitrate of silver is next provided

containing about two pennyweights of silver to the quart of distilled water, into which the article is immersed until it assumes a black colour all over; it is then placed in clean cold water, and afterwards dipped in a solution of chloride of gold, washed again, and allowed to dry spontaneously. The object is now ready to be placed in the bath, where it will receive the deposit very readily.

The above method of rendering non-metallic substances conductors of electricity is particularly applicable to the coating of insects, flowers, and other delicate objects of nature.

Flowers, &c., may also be dipped in a rather weak solution of nitrate of silver, and then be exposed to the fumes of phosphorus under a glass; or the object *b*, after it has been dipped in nitrate of silver, may be placed in a bottle A charged with hydrogen, or phosphuretted hydrogen.



Daguerreotypes may also be copied by the electrotype process, thus:—A portion of the back of the daguerreotype is to be cleaned by scraping it, or by applying a single drop of nitric acid, which is then to be wiped off; a little chloride of zinc is now put on the clean spot, and a small piece of thin pewter solder. A thickish copper wire, having one end flattened, is now placed in the flame of a candle or lamp, and being brought in contact with the picture, the heat is to be continued until the solder runs. The back of the daguerreotype may now be coated with wax, and may *then be placed in* the bath to receive the deposit of *copper. The electrotype* will be found easily separable

from the pictures, and it should be slightly gilt, in order to protect it from oxidation.

Another useful application of the art of electrotype the invention of Mr. Palmer, termed by him *glyphography*, a description of which process we give herewith:—

"A piece of ordinary copper plate, such as is used for engraving, is stained *black* on one side, over which is spread a very thin layer of *white* opaque composition, resembling white wax, both in its nature and appearance; this done, the plate is ready for use.

"In order to draw properly on these plates, various sorts of points are used (according to the directions here given), which remove, wherever they are passed, a portion of the white composition, whereby the blackened surface of the plate is exposed, forming a striking contrast with the surrounding white ground, so that the artist sees his effect at once.

"The drawing, being thus completed, is put into the hands of one who inspects it very carefully and minutely, to see that no part of the work has been damaged, or filled in with dirt or dust; from thence it passes into a third person's hands, by whom it is brought in contact with a substance having a chemical attraction or affinity for the remaining portions of the composition thereon, whereby they are heightened *ad libitum*. Thus, by a careful manipulation, the *lights* of the drawing become thickened all over the plate equally, and the main difficulty is at once overcome: a little more, however, remains to be done. The depth of these non-printing parts of the block must be in some *degree proportionate* to their width; consequently, the *larger breadths of lights* require to be thickened on the

plate to a much greater extent, in order to produce this depth. This part of the process is purely mechanical, and easily accomplished.

"It is indispensably necessary that the printing surfaces of the block prepared for the press should project in such relief from the block itself, as shall prevent the probability of the inking-roller touching the interstices of the same whilst passing over them; this is accomplished in wood engraving by cutting out these intervening parts, which form the lights of the print, to a sufficient depth; but in glyphography the depth of these parts is formed by the remaining portions of the white composition on the plate, analogous to the thickness or height of which must be the depth on the block, seeing that the latter is in fact (to simplify the matter) a *cast* or *reverse* of the former. But if this composition were spread on the plate as thickly as required for this purpose, it would be impossible for the artist to put either close, fine, or free work thereon; consequently the thinnest possible coating is put on the plate previously to the drawing being made, and the required thickness obtained ultimately as described.

"The plate thus prepared is again carefully inspected through a powerful lens, and closely scrutinised, to see that it is ready for the next stage of the process, which is to place it in a trough and submit it to the action of a galvanic battery, by means of which copper is deposited into the indentations thereof, and, continuing to fill them up, it gradually spreads itself all over the surface of the composition, until a sufficiently thick plate of copper is obtained, which, on being separated, will be found to be a perfect cast of the drawing which *formed the clichée.*

"Lastly, the metallic plate thus produced is soldered to another piece of metal to strengthen it, and then mounted on a piece of wood to bring it to the height of the printer's type. This completes the process, and the glyphographic block is now ready for the press.

"It should, however, have been stated previously, that if any parts of the block require to be *lowered,* it is done with the greatest facility in the process of mounting."

For the purpose of coating iron or zinc with copper, various solutions are employed.

1. Add to a solution of sulphate of copper a solution of cyanide of potassium, which will form a greenish precipitate; care must be taken to avoid breathing the fumes arising during this part of the process, as they are highly injurious. The precipitate is to be washed several times with cold water, and lastly dissolved with cyanide of potassium.

2. Pour into a solution of sulphate of copper, a solution of ferrocyanide of potassium, until no further precipitation takes place. Wash the precipitate as before. Cyanide of potassium will dissolve the precipitate. It is recommended to work this solution hot.

3. A very good solution for coppering may be made by dissolving about 8 ounces of sulphate of copper in one quart of hot water; when the solution is cold, add liquid ammonia (sp. gr. ·880) gradually, stirring well after each addition, until the precipitate at first formed becomes re-dissolved by the ammonia. Now add a strong solution of cyanide of potassium, until the blue colour of the ammonio-sulphate of copper disappears. An excess of cyanide must then be added; the solution should be worked at a temperature of about 130° F.

The chloride or acetate of copper may be used instead of the sulphate, the former being preferable to the latter, but more expensive. Solutions thus made may be worked cold. Two cells of the battery described at page 7 will be found to answer admirably, for the purpose of depositing from these solutions.

Articles of iron which are to receive the deposit of copper should be previously soaked in a strong solution of caustic alkali, either soda or potassa, made by adding to either of these salts some recently slaked lime; the clear liquor proceeding from which is to be used for the purpose of removing any grease which may attach to the article, which is then to be well washed and immersed in a "pickle," consisting of—

Sulphuric acid	1 pound.
Hydrochloric acid	2 ounces.
Water	1½ gallon.

After the iron article has remained in this pickle for a short time, it may be removed, and well washed and scoured with sand and water, applied with a very hard brush.

Articles of zinc may be placed in the alkali, and then steeped in the following pickle:—

Sulphuric acid	1 pound.
Water	2 gallons.

After pickling, the articles may be scoured with sand if they require it, which is seldom the case, unless the work is old and greasy, in which case the brush and sand will readily remove any stains which may present *themselves* after pickling.

BRONZING.

When an electrotype is obtained, or a surface of iron or zinc coated with copper, a bronze appearance may be imparted by any of the following mixtures, which should be laid on with a soft brush, and allowed to dry; after which a somewhat harder brush should be briskly applied to the object, until it has become thoroughly brightened. Should the bronze, however, appear too uniform and want relief, a little of the composition should be rubbed off the raised surfaces, in order to give an effect of light and shade. This may be done to suit the taste of the operator.

As the bronzing mixtures are of different colours, and are to produce various effects, care should be taken never to apply any two of them with the same brush, without previously washing it.

Black Bronze.—Dissolve platinum in nitro-hydrochloric acid, and evaporate to dryness, or to crystallisation. Dissolve this in spirit of wine, ether, or water. A few drops of this solution may be mixed with any of the bronzing powders, such as crocus, sienna, rouge, &c. It is well to gently heat the article to be bronzed, previous to applying this composition. The projecting portions of the article may be lightened, if requisite, by applying a little liquid ammonia to them with a piece of chamois leather.

Brown Bronze.—Rouge, with a little chloride of platinum and water, will form a chocolate brown of considerable depth of tone, and is exceedingly applicable

to brass surfaces, which are required to resemble a copper bronze.

Parisian Bronzes.

I.

Plumbago	1 ounce.
Sienna	2 ,,
Rouge	½ ,,

Add a few drops of hydrosulphate of ammonia and water.

II.

Chromate of lead	2 ounces.
Prussian blue	2 ,,
Plumbago	½ pound.
Sienna powder	¼ ,,
Lac carmine	¼ ,,

Add sufficient water to make a paste. To this may be added either chloride of platinum, or hydrosulphate of ammonia, according to the taste of the manipulator.

Another bronze may be made by mixing a little rouge, crocus, and hydrosulphate of ammonia in water; this should be applied several times, in order to give a body to the bronze.

Having given the principal facts connected with the electro-deposition of copper, sufficient I hope to enable the student to pursue the subject with ease and success, I now proceed to describe the various processes of Electro-Plating, in which I trust to present to the reader some useful practical information.

ELECTRO-DEPOSITION OF SILVER.

The most important of all the arts of electro-deposition is that denominated "electro-plating." This beautiful art is now practised to a vast extent in London, Sheffield, Birmingham, and Paris. Articles, chiefly

made of German silver, are coated with fine silver, and thus, to a great extent, supersede the ordinary Sheffield and Birmingham plate; whilst old articles from which the silver has worn off can be replated, and thus rendered equal, and in some instances, superior to new.

Previous to the discovery of this art, when the silver had disappeared from the surfaces of plated articles by long usage, they became useless, as there was no process known by which the articles could be re-silvered.

Since the first introduction of the art, many have worked it with considerable success, and in the principal towns in England, Ireland, and Scotland, there are manufactories in which, annually, a vast amount of silver is deposited upon articles of various construction, and yet there is no superabundance of electro-platers; for I believe that if there were ten times the number, they would all do well, and for this reason: — the amount of plated goods now manufactured all over the kingdom far exceeds that made in the old days of Sheffield and Birmingham plate; and the silver which is deposited on these goods must be replaced as it wears off, in the progress of time, by the electro-plater. Again, many persons now use plated German silver goods in preference to silver, either owing to their superior beauty, their being less tempting to the marauder, or more economical to purchase. And when we bear in mind the vast quantity of electro-plate which is to be found in the hotels, restaurants, and private houses in the united kingdom—which is daily having its silver rubbed and scrubbed off, there is good reason to believe that the electro-plater's services will be *extensively required,* in proportion as the manufacture *and consumption* of electro-plate progresses.

There are many solutions employed in depositing silver upon various metals, from which we will select those most likely to succeed with the beginner and the practical man. The proportions of the materials used being the same in small or large operations, the manipulator may easily make up either of the following solutions in any quantity he pleases, from a pint to 1000 gallons or more.

Silver Solutions.—In making any of these solutions, perfectly *fine* silver must be employed; or, if it is desired to use standard or other impure silver, it will be better to purify the silver by first dissolving it in nitric acid; then add about one quart of cold water to the acid solution obtained from dissolving four ounces of silver. Now throw in a few pieces of sheet copper to precipitate the silver, and proceed as described at page 93. When the pure silver is thus obtained, it is to be again dissolved in two parts water and one part nitric acid.

Solution I.

Fine silver	1 ounce.
Nitric acid	about 1 ,,
Water	½ ,,

Put the silver carefully into a Florence flask, and then pour in the acid and water; place the flask on a sand bath for a few minutes, taking care not to apply too much heat, and as soon as chemical action becomes violent, remove the flask to a cooler place, and allow the action to go on until it nearly ceases; when, if there be silver still undissolved, the flask may be again placed on the sand-bath until the silver disappears. If, *however, the acid* employed has been weak, it may be *necessary to add a little* more. The red fumes formed

when chemical action is going on disappear when the silver is dissolved or when the acid has done its work. If a little black powder be visible at the bottom of the flask, it may be taken care of separately, as it is gold. I have frequently found gold in the silver purchased of a refiner; in some instances more than sufficient to pay the expense of the acid employed.

The nitrate of silver formed during the above operation should be carefully poured into a porcelain or Wedgwood capsule, and heated until a pellicle appears on the surface, when it may be placed aside to crystallise. The uncrystallised liquor should then be poured from the crystals into another capsule, and heat applied until it has evaporated sufficiently to crystallise. When this is done, the crystals of nitrate of silver are to be placed in a large jar or other suitable vessel, and about three pints of cold distilled water added, the whole being well stirred with a glass rod until the crystals are dissolved.

A quantity of carbonate of potassa is now to be dissolved in distilled water, and some of the solution added to the nitrate of silver, until no further precipitation takes place. It is advisable occasionally to put a little of the clear solution in a glass, or test-tube, and to add a few drops of the solution of potassa, in order to ascertain whether all the silver is thrown down, or otherwise; as soon as the application of the alkaline solution produces no effect upon the solution of nitrate of silver, this operation is complete.

The supernatant liquor (that is, the fluid which remains above the precipitate) should next be carefully poured *off the precipitated* silver, and fresh water added; this is *gain allowed to* settle, and the water poured off

before, which operation should be repeated several times in order to wash the precipitate thoroughly.

A quantity of cyanide of potassium is then to be dissolved in hot or cold water, and rather more than is sufficient to dissolve the precipitate added. In a few minutes the carbonate of silver will be dissolved by the cyanide, but in all probability there will be a trifling sediment at the bottom of the vessel, which may be separated from the solution by filtration, and preserved, as in all probability it will contain a little silver.

Sufficient water is now to be added to make one gallon of solution. Should the solution be found to work rather slowly at first, a little of the solution of cyanide may be added from time to time, as it is required: but it is preferable, in working a new solution, to have as small a proportion of cyanide as possible, otherwise the articles may *strip*, but more especially if they are composed of German silver.

When a silver solution has been worked for some length of time, it acquires organic matter, and is then capable of bearing, without injury, a larger proportion of cyanide.

It is necessary that the nitric acid employed for dissolving silver should be of good commercial quality, if not chemically pure, for if it contains hydrochloric acid (which is not an unfrequent adulteration), a portion of the silver dissolved will become precipitated in the form of a white flocculent powder (chloride of silver), and the success of the operation is thereby impaired.

Solution II.—Dissolve two ounces of silver, in *two parts nitric* acid and one part water, and crystal*lise as before, then* drain and dry the crystals *thoroughly. Dissolve* the crystals in about half a

gallon of distilled, or rain, water. When the nitrate of silver is thoroughly dissolved, pour into the solution gradually, stirring all the time, a strong solution of cyanide of potassium (about half a pound of cyanide to one quart of water). A dense white precipitate will be formed, and this must be allowed to repose for awhile and the clear liquor tested to ascertain if all the silver has been thrown down. Put a little of the clear liquor in a wine glass or "test-tube," and add to it a drop or two of the cyanide solution. If this assumes a milky appearance, more cyanide must be added, but this must be done cautiously, otherwise the precipitate will become redissolved by the cyanide. If by chance an excess of cyanide has been added, a little nitrate of silver solution must be poured in, which will combine with the excess and thus properly balance the proportions.

The precipitate must now be allowed to subside, when the clear liquor is to be poured off and washed as before. Strong cyanide solution must next be added, when the precipitate (cyanide of silver) will become dissolved. As it is necessary that a certain amount of free cyanide should be present in the silver bath, the remaining cyanide solution must be added, and well stirred in.

Solution III.—A solution for depositing solid silver was patented by Mr. Alexander Parkes in 1871. One ounce of fine silver is converted into nitrate as usual, and the silver thrown down in the form of oxide by a solution of caustic potash. The oxide is then dissolved in a solution of cyanide of potassium made by *dissolving 16* ounces of cyanide in two gallons *of water. In* working the above process we imagine

that the cyanide should be of first-rate quality, otherwise with so small a proportion of silver to the gallon (half an ounce) the operation would be very slow. Some commercial cyanide we have met with would be useless for the above solution.

Solution IV.—One ounce of fine silver treated as before, and dissolved in three pints of distilled water. Precipitate with a strong solution of common salt, and wash, as above directed. Dissolve the precipitate with a strong solution of cyanide of potassium, taking care not to add much more than will dissolve the chloride of silver. Filter carefully, at least once through the same filtering paper and once through clean filtering paper, and then add enough distilled water to make one gallon of solution.

The above solution is very useful when it is desired to plate an article delicately white, but the silver is liable to strip when the burnisher is applied to it. This solution, however, may be employed with less fear of the work stripping, if it be used weaker, with a small surface of anode and feeble battery power.

Under all circumstances this solution is more applicable to surfaces which only require to be scratch-brushed, or which are to be left *dead*. Chased figures, clock-dials, cast metal work, &c., may be admirably plated with this solution.

Solution V.—One ounce of fine silver, as before, and the crystals dissolved in three pints of distilled water. Add strong solution of cyanide of potassium until no further precipitation takes place. If too much cyanide is added, it will re-dissolve the precipitate. Pour off the supernatant liquor and wash the silver as *before. Now add* strong solution of cyanide to dissolve *the precipitate.* Make one gallon with distilled water.

The solution should have a moderate excess of cyanide, and it must be filtered before using.

Solution VI.—A silver solution may be made by dissolving one ounce of silver as before. Dissolve the crystals in one pint of distilled water. Next be prepared with a large vessel full of lime-water, made by adding recently slaked lime to an ample quantity of water, which, it must be remembered, dissolves but a very small per-centage of lime. To the clear lime-water is to be added the solution of nitrate of silver, which will be converted into a dark brown precipitate (oxide of silver). When all the silver is thrown down, the clear liquor is to be poured off, and the precipitate washed as before. Now add strong cyanide of potassium solution to dissolve the oxide of silver, and make one gallon with distilled water.

This makes a very excellent solution, although it is somewhat troublesome to prepare.

Solution VII.—Dissolve in one gallon of water one ounce and a-quarter of cyanide of potassium, in a stone-ware or glass vessel. Fill a porous cell with some of this solution, and place it in the larger vessel; the solution should be the same height in both vessels. Then put a piece of sheet copper or iron, connected with the wire which proceeds from the zinc of the battery, into the porous cell. Place in the stone vessel a piece of stout sheet silver, which must be previously attached to the wire issuing from the copper of the battery. It is well to employ several cells alternated, for this purpose, when a large quantity of solution has to be prepared; that is to say, the zinc of one battery should be united by a wire with the copper of the next, and so on. In a few hours the solution in the large

vessel will have acquired sufficient silver, and the solution may be at once used. The porous cell is to be removed, and its contents may be thrown away.

In working this solution at first it is necessary to expose a rather large surface of anode, and small quantities of cyanide must be added occasionally until the solution is in brisk working order.

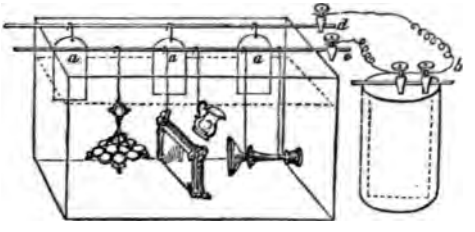
This is one of the best solutions, when carefully prepared, and is less liable to strip than many others.

Solutions of silver may be prepared by precipitating the silver from the solution of nitrate with ammonia, soda, magnesia, &c., &c., but for all practical purposes the solutions I., IV., V., VI., and VII., may, if carefully prepared, be depended upon.

When it is desired that the articles should come out of the bath having a *bright* appearance, a little bisulphuret of carbon is added to the solution. This is best done in the following manner:—Put an ounce of bisulphuret of carbon into a pint bottle containing a strong silver solution with cyanide in excess. The bottle should be repeatedly shaken, and the mixture is ready for use in a few days. A few drops of this solution may be poured into the plating bath occasionally, until the work appears sufficiently bright. The bisulphuret solution, however, must be added with care, for an excess is apt to spoil the solution. In plating surfaces which cannot easily be scratch-brushed, this brightening process is very serviceable. The operator, however, must never add too much at a time.

In making up any of the foregoing solutions the weights and measures employed are troy, or apothecaries' weight, and imperial measure, a table of which will be given at the end of this volume.

Having at command any of the solutions described, the operator may next arrange the battery. A plate *a*, *a*, *a*, or sheet of silver, is to be attached to the wire issuing from the copper of the battery *b*, and supported by a brass rod *d*; this may be done either by soldering them together or uniting them with a suitable binding screw; but the best plan of attaching the anode, or



sheet of silver, to the copper wire is as follows:—Cut a strip to within half an inch or so; this strip may be united to the wire by a binding screw or soldered. If cast plates of silver are used, it is advantageous to have them cast with an extra piece, about three inches long at the corners, to attach the copper wire to.

The object in adopting either of the above arrangements is to prevent the copper wire entering the bath, as this is much impaired by allowing the copper to be immersed in the cyanide solution, whether deposition is taking place or not. Copper, if left in the bath for any length of time, even unconnected with a battery, will reduce a portion of the silver from the solution, an equivalent of the copper taking its place. This is especially the case when a large quantity of free cyanide is present.

A brass rod e, with a binding screw soldered or screwed *on one end of it,* is now to be attached to the negative

wire of the battery. The articles to be coated may be suspended to this rod by pieces of clean copper wire; the wire used for this purpose may be rather thin, yet sufficiently strong to bear the weight of the articles. The thinner the wire is the less mark will be made upon the articles coated—a very important consideration in some cases, especially where spoons and forks are to be plated. This wire is termed "slinging wire." The size I generally prefer for spoons and forks is about $\frac{1}{3}$rd of an inch in thickness. The rods from which the anodes and goods to be plated are suspended must be kept quite clean and bright, by rubbing with emery cloth.

Preparation of New Work to be Plated.—German silver spoons and forks may be first placed in a hot solution of caustic soda or potassa (made by mixing recently-slaked lime with a concentrated hot solution of either soda or potassa, and allowing the lime to subside, the liquor is ready for use when further diluted), in order to remove any grease which may be upon them. A few minutes will effect this, as the caustic alkali very readily converts the small amount of grease generally on these articles into a soapy substance, easily removable by water. This process, however, is not indispensable; I seldom adopt it.

The spoons, &c., may now be well brushed with either powdered pumice-stone or powdered bath-brick (I prefer the latter) and water—a hard brush being applied to the purpose. This cleansing process is carried on until all the polish of the spoons is removed; and *the fingers which* hold the articles should be kept well *charged with the* powdered material, to prevent any *grease or perspiration* being imparted to the work. In

cleaning spoons, it is advisable to begin at the inside of the bowl, and then to proceed to the other parts; lastly, going over the whole surface lightly, to render it uniform after the necessary handling it has been subjected to. A little practice will soon render the operator expert in these important details. The spoons, &c., are to be placed in clean cold water as soon as they are brushed, and are then ready for the bath. The slinging wires may now be attached.

When a solution is newly made, the work is apt to be irregularly coated at first, therefore it may be necessary to take the articles out of the bath about ten minutes after their first immersion, and to give them another slight rub with the brush and powdered material as before, when they should be again rinsed and placed in the solution.

If it is desired to give the spoons a very strong coating of silver, it is well, after a few hours' immersion, to remove them from the bath, and to submit them to the action of a lathe scratch-brush (consisting of a "chuck," with several bundles of fine brass wire attached to it, upon which beer or weak ale is allowed to run from a small barrel, with a tap to it, from above). This process will burnish down the white "burr," as it is called and which consists of minute crystals of fine silver, and will prevent the coating from becoming *rough*. After the articles are scratched they should be rinsed in clean water, and again placed in the bath until done. The spoons may be lightly brushed over with moistened silver sand instead of being scratch-brushed, but the latter is *preferable*. When the goods have received *the required coating* they are again scratched, and can *then be finished, either* by the burnisher or polisher.

If the operator desires to know exactly how much silver is deposited on a given quantity of work, this may be done by weighing the article before and after immersion; or, by weighing the anode each time, he may form a tolerably correct estimate of the amount of silver deposited, for the anode generally supplies the solution with the amount of silver taken from it by the articles coated, that is to say, if all circumstances have been favourable.

When the articles are first placed in the bath, a sufficient surface of anode should be exposed (that is, immersed in the solution) to enable the goods to become whitish in the course of a few seconds. If they assume this appearance the very instant they enter the bath, the process is going on too quickly, and the articles will be liable to "strip." I regulate the speed of the operation of electro-deposition almost entirely by the anode, and I prefer exposing a small portion of this electrode at first, until the goods are uniformly covered, when the anode is lowered, little by little, until sufficient is exposed to carry on the operation with requisite speed. But the state of the solution and the battery must also be carefully attended to.

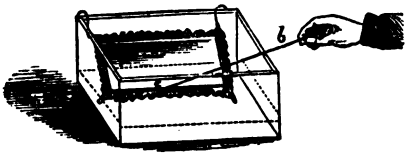
Large goods—for example, tea-pots, cruet-frames, tea-urns, &c., may be treated in the same way as spoons and forks, but care must be taken that no impression of the fingers be left on any of the plain surfaces, as in such case a roughness will occur at that part.

Preparation of Old Work to be Plated.—Sheffield or Birmingham plated cruet, soy, and liquor *frames, &c., from* which the silver has worn off, should *first have the bottom* separated from the wire, either by *unsoldering* or unscrewing, as the case may be. The

bottom, if it is very rough, may be rendered smooth by means of emery cloth, or pumice-stone and water, and emery cloth afterwards. It may be finished with water-of-Ayr stone. The cruet-frame wire may generally be made smooth with emery cloth only.

As soon as the parts of the frame are smooth, the edges, feet, &c., may be brushed with a hard brush and powdered Bath brick, until all the interstices are quite clean. If there be any verdigris on any part of the frame it may be removed immediately by applying a few drops of hydrochloric acid ("spirit of salt") to the part. When the edges have been well brushed, the frame should be brushed all over in the same way, and it is then ready for the solution. But if the edges or mounts are lead ("silver edges" they are generally termed), it will be necessary to apply, with a rather soft brush, a solution made by dissolving four ounces of mercury in nitric acid, and adding about half-a-pint of cold water. This solution is to be lightly brushed over the lead mounts only; the article and brush are then to be well rinsed, and the brush and plain water again applied in the same way. The solution of mercury will turn the edges black, or dark grey, but the subsequent brushing will render them bright again. The frame is now to be well rinsed and is ready for the depositing bath. If, on its first immersion, any black spots exhibit themselves, the frame may be removed, again brushed over, and finally returned to the bath. If the edges do not receive the coating of silver as readily as the other parts, the solution may *require a little* more cyanide, or strengthen *the power of the battery*, or by increasing the surface *of the anode this may* be accomplished.

I have successfully coated these lead edges by applying a solution of sulphate of copper A, with a little free sulphuric acid in it, thus:—I dip one portion of the edge at a time in the solution of sulphate of copper, and with a piece of iron *b*, I touch the lead edge *c*, in solution, and this in an instant becomes coated with a bright deposit of copper. This is now rinsed, and the next part of the edge is treated in the same way, and so on. By this plan lead edges may be coated with great facility and certainty of success.



Generally, underneath the bottoms of cruet frames is a coating of tin; and as this metal is very troublesome to plate, unless in a solution made expressly for it, I prefer removing the tin, either by means of nitric or hydrochloric acid (the latter being rather a slow process), or with emery cloth and pumice; but nitric acid, employed with care, is the quickest plan.

When it is wished merely to whiten an article with silver, the amount deposited being of no consideration, solution No. 4, described at page 44, should be used. Let us suppose that a time-piece dial be the object to be whitened. The dial is first cleaned with a brush in the ordinary way, until all the old silver (if any) is removed; it is then rubbed with a piece of chamois leather and finely powdered Bath brick, slightly moistened; it is better *to* pass the leather over the surface *in circles*, so as to *render the face* as uniform as possible and to prevent *the deposit from* being *patchy*. The dial is then to be *rinsed in quite* clean water and suspended in the bath.

If the finger has been allowed to touch the face of the dial, it will be found that that part exhibits a dulness corresponding to the form of the skin of the finger, and it will be necessary to rub the dial as before with the chamois leather. The dial should be supported by the edges only. A few minutes' immersion will be sufficient to whiten a dial. When done, it is to be plunged into boiling water, and allowed to dry spontaneously, or be placed in perfectly clean box saw-dust.

Articles which are to be left with a dead-white surface, may be prepared in the same way, but they require to remain longer in the bath; in fact, till they assume the characteristic dead-white appearance. They are then to be placed in boiling water, and finally in box-dust, the latter being removed by means of a soft brush.

When it is necessary to whiten goods very quickly, the solution may be weakened with *hot* water, and the temperature raised to about 130° Fahr. The surface of anode exposed must be less than if the solution were to be worked cold. Moving the articles about in the solution occasionally, ensures uniformity and improves the whiteness by giving it a slight transparency.

When any of the solutions have been in use for some length of time, their conductibility may be augmented by adding a little cyanide of potassium. After the first few days the solution generally works better than when newly made; therefore it is not advisable to make any alteration in it until it begins to work rather tardily, when the additional cyanide may be added. I have invariably found that a solution that has been *worked for several* years has given better results than *one recently made*, and I have never yet been con-

pelled to resupply the solution with silver; this is simply because I have taken care to work with a sufficient *surface* of anode, with battery power of feeble intensity, and with enough free cyanide in solution to cause the anode to yield as much silver to the bath as the plated articles have from time to time removed from it.

Iron is by no means an easy metal to coat with silver. It may, however, be successfully plated with care. The iron article should first be well cleaned and rendered free from rust, either by rubbing with emery cloth, or by dipping it into a pickle composed of

Sulphuric acid	2 ounces.
Hydrochloric acid	1 ounce.
Water	1 gallon.

It may remain in this pickle until the oxide or rust becomes easily removable by a brush and wet sand. If it be found, on removing the articles from the pickle, that the oxide does not brush off easily, it should be returned to the pickle-bath. When the surface is merely rusty, strong hydrochloric acid alone will remove the rust and render the article at once clean and ready for the sand-brush. The articles when cleaned and well rinsed, may be placed in the alkaline solution of copper bath, described at page 35, and allowed to remain until they have received a slight coating; they may then be rinsed and placed in the silvering bath; or the articles may be electro-brassed by any of the processes hereafter to be described, and then immersed in the plating bath.

It is better to deposit a coating either of brass or *copper upon an iron* surface, to insure success. Copper *will adhere well to* iron, but silver will not, therefore

copper acts the useful part of a "go-between," thereby preventing the disagreement that might arise were two metals, so antagonistic to each other as silver and iron, allowed to come in contact.

The solution in which iron is to be plated should be weakened with about fifty per cent. of water.

Britannia metal, pewter, and all combinations of lead and tin, are best plated in a solution containing a good deal of free cyanide. Deposition should be suffered to take place quickly at first, so as to insure the deposit going well all over the article. A larger surface of anode, also, must be exposed than would be required for German silver work—probably three times the surface.

The battery power must be energetic, but not too intense. Two 4-gallon cells of the battery described at page 10 will be sufficient for objects of considerable size. Articles made of Britannia metal, &c., should not be disturbed while in solution. They may, however, be shifted now and then so as to expose a fresh surface to the anode, for the sake of causing uniformity of deposit, but it is not advisable to let the solution be agitated more than is absolutely necessary. This caution, however, is chiefly applicable to the period when the articles are first immersed in the bath.

The goods may be prepared for plating by brushing them over with silver sand and water, with a moderately hard brush, instead of the powdered Bath brick used for other metals. The articles may be cleansed from grease by placing them for a few minutes in a hot solution of caustic soda.

If the articles, when they have been placed in the *plating bath for a few* moments, present an unequal

surface, it is advisable to remove them, and have them brushed over again as before; then, after well rinsing, they should be quickly returned to the bath and allowed to remain without further disturbance if possible.

The readiest mode of plating articles of lead, tin, or zinc, is to previously cover them with a film of brass, in the brassing bath: or with copper, in the alkaline coppering bath. Either brass or copper will adhere firmly to the surface of these metals, and the silver may be deposited on the coppered or brassed surface with perfect facility. After the articles have been removed from the copper or brass bath, they should be well scratch-brushed and rinsed before placing in the plating bath.

When an article has been plated and is found to strip or blister in many places, it will be necessary to remove all the silver from the surface and plate it again more carefully. There are two kinds of *blistering;* the first is the non-adherence of the silver to the article coated; the second, the blistering or *doubling* of the metal of which the article is composed. When the blistering is of the first kind, the article, after the silver has been removed by the process described below, may be rendered smooth with water-of-Ayr stone previous to being replated; but if the metal itself has blistered when the burnisher was applied to it, the blister must be scraped, buffed, or filed down, and the surface made smooth in the ordinary way.

The silver is removed (or "stripped") from articles thus:—Put some strong sulphuric acid into a stone jar *or enamelled saucepan*, and add a few crystals of nitrate *of potassa (saltpetre)*. Apply heat until the nitrate is dis-

solved. When this solution is very hot the articles are to be immersed, and occasionally moved about until the silver becomes entirely dissolved from the surface. The removal of the silver will become manifest by the metal beneath being exposed at the edges. The operation must then be closely watched in order to prevent the articles remaining longer in the solution than is absolutely necessary. If the above solution does not remove the silver quickly, more nitrate of potassa must be added from time to time, and the heat augmented if required.

When a quantity of things have been stripped in the solution it will begin to work slowly, and a mass of crystals will be found at the bottom of the vessel as it cools. It will be better now to add a quantity of cold water to the solution, and to immerse in it some pieces of zinc, which will throw down the silver in a metallic state, but in minute crystals of a greyish colour. By dropping a little hydrochloric acid into the solution the operator will be able to judge whether all the silver is deposited or not. The acid will form a white precipitate* so long as there is any silver in solution. When all the silver is precipitated, the supernatant liquor may be poured off carefully and fresh water added to wash the precipitate, which process should be repeated several times in order to render the silver as clean as possible. The pieces of zinc should be removed before the final washing of the silver. The silver may now be dried and put into a crucible (being previously mixed with a little *dry* powdered potash), and heated in a furnace until all the metal is gathered into a button. During the process of fusion, a few crystals of nitrate of potash may be *carefully dropped into* the crucible. The silver thus *obtained will be perfectly* fine.

* Chloride of silver.

Or the silver may be precipitated from the *stripping* solution by means of common salt, when chloride of silver will be formed, which may be dried and fused in the same way as above, previously being mixed with a little soda or potassa, to form a flux.

The articles may be stripped in the plating bath, by suspending them in the place of the anode, but this plan is apt to injure the solution, by imparting to it a portion of the copper or other metal of which the article was made. Or the silver may thus be precipitated upon the end of a wire, enclosed in a linen bag to collect the small granules of silver which will fall from the end of the wire. A powerful current would strip the silver off in a very short time. A small quantity of solution containing excess of cyanide should be kept for this purpose alone.

Deposition of Silver upon Non-Metallic Substances.—Silver may be deposited in the same way as copper by the electrotype process, but as cyanide of potassium rapidly dissolves wax, it will not be advisable to employ moulds made of that material. Gutta percha is better, but even this substance is acted upon by cyanide of potassium. Moulds made of fusible metal are, however, more suitable for this purpose. When the cyanide solution of silver is employed for depositing upon or for copying non-metallic substances, the bath should have at least six times as much silver as that required for the ordinary process of plating.

A solution of nitrate of silver, if not too strong, will answer well for depositing upon plumbagoed surfaces, but this solution must not be employed for depositing *upon copper or other* metallic surfaces.

The backs of copper moulds which are to be coated

with silver should be covered with some material to prevent the silver being deposited on those surfaces; for this purpose it has been recommended to boil a little pitch in a strong solution of potassa, which will form a sediment. Some of this sediment is added to a quantity of melted pitch, at which time a violent action ensues, white fumes being evolved. Allow this action to subside, and the resulting material will be ready for use. Melted gutta percha will also answer tolerably well for protecting the backs of metallic moulds.

There are many other practical points in the electro-deposition of silver, which we deem it advisable, for the reader's convenience, to give in the form of an Appendix at the end of this work, to which he will prudently refer when desirous of practising the art of electro-plating, &c.

ELECTRO-DEPOSITION OF GOLD.

In importance, electro-gilding is second only to the art of electro-plating; and it is carried on in much the same way. The solutions of gold, however, should be generally worked *hot;* hence the operation of gilding is conducted in a much shorter space of time than is required for plating. An article may be well and strongly coated in a few minutes, whilst it would require several hours to electro-plate an article well.

There are many forms of solution in use amongst electro-metallurgists, all of them varying in the proportion of gold to the gallon of water, and in the amount of cyanide employed. These solutions are all of them *easily made, and any* of them can be well worked by a *skilful operator.* Some gilders use five or six penny-

weights of gold to the quart of solution—others as much as eight or ten dwts.; but I have generally found that a solution containing less gold will give better results than one richer in the metal, independent of the advantage in point of economy. I have observed that a bath containing five or six dwts. of gold to the quart of water, and the necessary proportion of cyanide, and worked with several united cells of Smee's battery, has required a much larger surface of anode to be exposed to a given surface of negative electrode (that is, the article to be gilt) than would be required to gild an article in a solution containing one and a half dwt. to the quart of solution worked with a single cell of a constant battery. Hence I infer that the weaker solution is the better conductor of the two.

Gold Solutions.—Solution I.—Dissolve in a Florence flask one pennyweight and a half of fine gold in two parts hydrochloric acid and one part nitric acid (*aqua regia*), applying gentle heat to accelerate chemical action. When the gold is all dissolved, pour the chloride of gold thus formed into a porcelain capsule and apply moderate heat until all the acid is evaporated. A red mass will result. It is advisable, when the acid is nearly expelled, to move the capsule round and round, so that the liquid may be dispersed over a large surface of the vessel. It will be found that the liquid will cease to flow when the acid is expelled, at which period the operation is complete. If too much heat is applied the gold will become reduced to the metallic state, which may be known by the red mass acquiring first a yellow tinge, and next a gold bronze will be observed at the bottom of the capsule. In such a case it will be necessary to add a little more of the mixed acids in the same

proportion as before, which will at once redissolve the reduced gold.

When the acid has been driven off the chloride of gold, about half a pint of cold distilled water is to be added, which will at once dissolve the chloride, forming a bright straw-coloured solution. Allow this to subside for a few minutes, as in all probability there will be a small amount of white precipitate at the bottom of the vessel, which is chloride of silver; the solution of gold must be carefully poured off from this precipitate, as it is soluble in cyanide of potassium, and its presence in the resulting solution may be prejudicial. A little distilled water may be poured into the capsule, to rinse away all the gold, taking care not to allow the sediment to come away with it, when transferring the rinsings to the solution of gold.

A little strong solution of cyanide is now added, gradually, to the solution of gold, and the whole stirred with a glass rod. The gold solution will instantly lose its yellow colour. A brown precipitate is formed by the solution of cyanide, and this solution must be added drop by drop until it produces no further effect upon the clear solution. The supernatant liquor is now to be carefully poured off, and fresh water added several times to wash the precipitate of gold—taking care not to waste any of the precipitate nor to add more cyanide than is *absolutely* necessary. When the precipitate is sufficiently washed, more of the solution of cyanide is added, which will at once dissolve the precipitate, forming a clear solution. The cyanide should be added in excess, say about twice as much as may be required to dissolve the *precipitate.* The concentrated solution of cyanide *of gold thus obtained* is placed over the fire or on

sand-bath until it is evaporated to dryness, when it may be again dissolved in cold water and filtered for use. Lastly, enough boiling distilled water is added to make one quart of solution, and a little additional cyanide added if the solution is found to work too slowly at first—but it is better not to use more cyanide than is necessary, otherwise the anode will become rapidly consumed and the gilding be of a "foxy" colour.

Solution II. Dissolve one and a half dwt. fine gold as before, and evaporate to dryness. Re-dissolve in half a pint of distilled water and precipitate the gold with ammonia, taking care not to add more ammonia than is necessary. Pour off the supernatant liquor and wash the precipitate as before. Now add sufficient cyanide of potassium to dissolve the precipitate. Evaporate to dryness, and re-dissolve with cold distilled water. The solution is then to be filtered, and distilled water added to make one quart. A little cyanide is to be added occasionally, as required.

Solution III. Dissolve one dwt. and a half as before, and when the half pint of solution of chloride is obtained, precipitate the gold with hydrosulphate of ammonia. A copious black precipitate is formed, which must be allowed to subside, and this substance then washed as before directed. Dissolve the precipitate with a lump of cyanide—say about half an ounce, or rather less; and evaporate to dryness. Then add water to make one quart.

Solution IV. Dissolve the same quantity of gold as before, but without evaporating the acid. Add a quantity of calcined magnesia, which will precipitate the gold in the form of an oxide. To the oxide add sufficient concentrated nitric acid (applying heat at the

same time) to dissolve the magnesia, when the oxide will be left in the form of a precipitate, which is to be well washed, and then solution of cyanide added to dissolve it as before. Evaporate and make one quart of solution with distilled water.

Solution V. Dissolve one ounce of cyanide of potassium in one quart of nearly boiling distilled water. About half fill a "porous cell" with the solution, and stand it in the vessel containing the bulk of the solution. Attach a piece of sheet copper to the wire issuing from the zinc of the battery, and place it in the porous cell. Put a piece of sheet gold, attached to the copper of the battery by a wire, in the outer solution, and allow the whole to remain in action until the solution has acquired about one pennyweight and a half of gold, which may be ascertained by weighing the gold before and after immersion. The porous cell may now be removed and its contents thrown away. The solution is now ready for use.

These solutions should be worked at a temperature of about 130° F., with one cell of a constant battery.

The solution of gold may be heated either in an enameled saucepan, or in a glass vessel placed in an iron pan containing water. The operator now proceeds to arrange his battery. The wire which issues from the copper of the battery is to be attached to a piece of fine gold, which may conveniently be done by soldering. The article to be gilt is to be suspended to the wire proceeding from the zinc of the battery.

Preparation of Articles to be Gilt.—Silver goods, such as cream ewers, sugar bowls, mugs, &c., should be well scoured inside with hot soap and water and silver sand, and if they are at all greasy, a little caustic soda

may be applied to them first. Or the mugs, &c., may be well scratch-brushed and then rinsed with boiling water. The insides only of these vessels are generally required to be gilt, in which case the outsides should be wiped dry before gilding. The negative wire (from the zinc of the battery) is to be attached to the handle of the vessel. The plate of gold is now to be carefully suspended in the centre of the vessel, taking care that it does not touch it; and the gold solution may be poured into the mug by means of a jug or other suitable vessel, until it reaches the upper edge. If it is desired to gild the extreme edge, the solution may be guided over it with a piece of wood or glass rod. In about five or six minutes the vessel will be sufficiently gilt, when the anode may be removed, the negative wire detached, and the solution poured into the bath. The article is at once to be rinsed with hot water, and may be scratch-brushed and burnished in the ordinary way. When cream ewers, &c., are so constructed that the solution will not reach the lip, &c., without overflowing, it is advisable to slightly tilt the vessel so as to cover as much of it as possible, and when it is gilt the lip may be dipped into a little gold solution, being attached to the battery the while; but in this case the outside of the lip will also receive a deposit. This may be prevented by coating the outer surface of the vessel with the composition which we have already described, p. 59. Vessels *which are to be gilt* inside only, should be placed on a *plate or dish to collect* any solution which may run over.

Silver brooches, pins, rings, thimbles, egg, salt and mustard spoons, &c., merely require to be scratch-brushed before gilding. After they have received the required deposit, they are again brushed, and if the colour be a little too pale or too red, the articles should be immersed in the bath again *for an instant*, and then plunged into boiling water, when they will assume a beautiful fine gold colour. When well rinsed in hot water, the articles are to be placed in box saw-dust, which may sometimes be advantageously kept hot for this purpose, in order to dry the goods as speedily as possible; but care must be taken that the box-dust be not allowed to char or burn, otherwise it will stain the articles.

Goods which are made of copper or brass entirely, may be dipped into nitrous acid ("fuming nitric acid" or "dipping acid") for a moment, and instantly plunged into clean cold water; after which process they should be again rinsed in fresh water, and at once placed in the gilding bath. Or such articles may be merely scratch-brushed, rinsed, and then placed in the bath.

If, when first put in the bath, copper or brass goods receive the deposit too quickly, the anode should be raised a little out of the solution, so as to expose a smaller surface, and the articles should be moved about a little, by which uniformity of deposit will be secured. In fact, it is advisable always to give the articles a gentle motion when first placed in the bath, until they have received a slight coating, when they may be allowed to remain steady until finished; but when it is required to deposit a stout coating, it will be advantageous to *move them occasionally*, to prevent the deposit taking *place unevenly.*

When goods are made of either copper or brass, with mountings of another metal, or if they have been previously plated or gilt, greater care must be observed, otherwise some parts will receive the deposit favourably while others will scarcely be coated at all. This applies more especially to goods which have mountings pewter-soldered upon them, which is frequently the case in common jewellery. In this case all the surfaces will receive the deposit but the solder, which, being a bad conductor of electricity, and more electro-negative than the other metal to which it is attached, will receive the deposit but tardily, if at all. I have frequently found that the smallest speck of pewter solder which has happened to be upon a brooch which I had to gild, has compelled me to deposit at least three times as much gold as the article required before I could cover the speck of solder; and in many instances not even then would deposit take place upon the offending spot. Having tried to amalgamate the solder with the gilt surface by means of nitrate of mercury, nitrate of silver, and both combined and alternately applied; and having scratch-brushed the tardy spot until I was heartily sick of pewter solder and everything which it contaminated, I at last hit upon a plan by means of which I have ever since been enabled to gild pewter solder with ease and certainty. I placed a single drop of an acid solution of sulphate of copper upon the solder spot, and then touched it with a piece of steel: in an instant the solder and surrounding surface received a bright deposit of copper (which could be strengthened by repeating the operation several times). The moment the article was *placed in the gilding* bath the spot became coated; in *fact—copper being* easier to gild than gold—this spot

received the deposit in preference, so that my difficulty was speedily and satisfactorily overcome. Many electro-gilders, I have no doubt, will find the above plan relieve them from a considerable amount of annoyance. Generally speaking, however, when the operator finds a difficulty in gilding pewter solder, it is owing to the bath requiring cyanide, or the exposure of a larger surface of anode; or may be the battery power is weak.

Instead of the above plan of coating pewter solder, the manipulator may put a drop of concentrated solution of silver upon the solder, as before, and, on touching the part with a piece of fine wire the solder will be coated with silver in an instant. I prefer the former plan, however, since copper receives the deposit of gold more readily than silver.

In gilding cheap jewellery, French and Birmingham fancy goods, and articles which are not required to have more than a *coloured surface* given to them, I have found it an economical plan to gild with a copper anode, and as the gold becomes exhausted from the solution, to add more gold from time to time, thus working from the solution instead of from the anode. By this arrangement, the operator is sure not to deposit more gold upon his work than is consistent with the scale of remuneration for doing the same.

Generally, it is only necessary to scratch-brush this class of goods; then having rinsed them in boiling water, they are to be dipped into the solution for an instant; a few seconds only being required to give the goods a beautiful colour.

Silver filigree brooches, &c., must be well scratched, *dipped in the bath* for a moment and then rinsed and *scratched again*: on immersion in the bath the second

time they will become more uniformly gilt. The surface of anode must be adequate and the battery power brisk, or the filigree work will not receive the deposit uniformly. The solder of filigree work is generally the most troublesome to gild, but if the current and other circumstances are favourable, the deposit should take place all over at once; a want of cyanide in the solution is a principal cause of difficulty in gilding filigree work. Gently moving the articles about in the solution, greatly adds to the beauty and uniformity of the result, if all other matters are favourable. The solution for gilding filigree goods should contain rather more gold than that for ordinary work, and the surface of anode exposed must be greater.

Metal pins, brooches, rings, &c., should be either "dipped" as before recommended, or well scratch-brushed before gilding. This class of goods may be done on a large scale, in a porcelain vessel like a colander, suspended in the bath. The goods, being placed in this, merely require to be touched, and occasionally stirred about by the negative pole of the battery, so as to cover those parts which have been in contact with each other.

Army accoutrement work, sword-mountings, &c., should first be prepared by cleaning with silver sand, soap and water, applied with a hard brush. The article may then be scratch-brushed, and placed in the bath until it has *nearly* acquired a sufficient coating, when it is to be removed, rinsed in warm water, and those parts which are required to be left *dead*, gently *brushed* over with powdered pumice or Bath-brick. *The article is* then returned to the bath and allowed to *remain until* finished. As soon as it has become

sufficiently gilt, the plain surfaces may be scratch-brushed, and then burnished.

I have induced my workpeople to burnish gilt-work with four-penny ale, instead of soap and water, and it has been considered by them a great improvement, since the burnisher seems to glide over the surface of the work with greater ease and smoothness, more especially when the gilding has been what is termed "hard" or "scratchy." Vinegar has sometimes been applied to this purpose, but not, I think, with such success.

In gilding German silver, the solution may be worked at rather a lower temperature, the solution weakened, and a less surface of anode exposed. German silver has the power of reducing gold from its solution in cyanide (especially if the solution be strong) without the aid of the battery; as also will brass receive a coating of silver in the plating-bath without the use of the current, therefore the solution should be weaker—in fact, so weak that the German silver will not deposit the gold *per se*; otherwise the deposit will take place so rapidly that the gold will peel off when being burnished, or even scratch-brushed.

When iron or steel goods are to be gilt, they should be first rendered free from grease, by being immersed in a solution of caustic soda or potassa; they are then to be well scratch-brushed—in fact, until they have acquired a slight coating of brass, from the wires of the brush. If sour beer is used for this purpose it will greatly facilitate the operation. The article should then be placed in the bath for an instant, then well scratch-brushed and dipped again. The solution employed for *iron or steel should* be much weaker than for any other *metal. I would* recommend the following:—

Ordinary solution	4 fluid ounces.
Water	20 ,,
Cyanide of potassium, about . . .	2 drachms.

This solution may be worked rather warm, but not so hot as the ordinary solution. Weak battery power should be employed, and small surface of anode, and deposition must be allowed to take place very slowly at first.

By scratch-brushing iron or steel articles with vinegar or dilute hydrochloric acid, a very good and adhesive coating of copper may be obtained upon the surface of the article, but the employment of the latter must be done with caution or the operator's clothes may be injured; a few drops of acid, however, to the pint of water is all that will be required.

The best method of preparing steel or iron articles for gilding, is to coat them with copper or brass in the same way as that recommended for plating these metals. Many steel articles, which only require a trifling deposit of gold, may be gilt without any further preparation than merely rinsing them in hot water. The articles then receive a momentary dip in the bath, and, being sufficiently gilt, are rinsed in hot water and dried quickly in hot box-dust, or in an oven.

Steel surgical instruments must be gilt with great care, in order that the edges be not rendered blunt by the operation. These articles should be placed in the bath without any preparation, as coating them with copper or brass, and then gold, may involve too much handling. A slight deposit is all that is necessary to *protect* the steel instrument from rust or corrosion.

Steel or iron keys should be first well scratch-brushed, *dipped into the bath* for a moment, and then brushed

again; lastly, allowing them to remain in the bath until sufficiently coated. These may be finished either by burnishing or polishing.

ELECTRO-DEPOSITION OF BRASS AND BRONZE.

It is far more difficult to deposit an alloy of two or more metals than one only; and this difficulty becomes greater when we require to deposit, as an uniform alloy, two metals whose electrical conditions are of an opposite character, as zinc and copper. From a solution consisting of zinc and copper in the proportions to form ordinary brass, it is easy to deposit the zinc alone, or the copper alone, by increasing or diminishing the power of the current, or by raising or lowering the anode; that is to say, by increasing or diminishing the surface of anode exposed to a given surface of object to be coated.

The difficulty in regulating all circumstances, so that an uniform result might be obtained by the operator, and so that the process of electro-brassing might be depended upon, has, in many instances, caused this useful art to be abandoned altogether by the manufacturer.

Many processes of electro-brassing have been published and patented in this country and on the continent, but all of them have the disadvantage of being more or less troublesome and uncertain to manage, even though the operator be a person well skilled in electro-deposition. But I think that several of these processes may be rendered commercially valuable if the solutions in the first instance are mixed *by persons acquainted* with chemical laws. Again, *there would be less* liability to failure, if the power of

the current employed was always regulated by the surface of goods to be coated; the amount of anode, also, being regulated by the same. If, on the contrary, the battery-power be too weak, or in excess, either the copper on the one hand, or the zinc on the other, will be deposited alone.

In making up either of the following brassing solutions, the proportions may be varied to a considerable extent, and where the carbonate of potash forms part of the formula, liquid ammonia may be substituted.

I. De Salzede's Processes.

I.

Cyanide of potassium	12 parts.
Carbonate of potassa	610 ,,
Sulphate of zinc	48 ,,
Chloride of copper	25 ,,
Nitrate of ammonia	305 ,,
Water	5000 ,,

Dissolve the cyanide of potassium in 120 parts of the quantity of water above specified, and then dissolve the carbonate of potassa, sulphate of zinc, and chloride of copper in the remaining water, raising the temperature to about 150° F.; and as soon as the salts are well dissolved add the nitrate of ammonia, frequently stirring until the latter is dissolved. The solution may now be allowed to stand for a few days, in order that the sediment formed may become precipitated, when the clear liquor is to be drawn off, and is ready for use.

II.

Cyanide of potassium	50 parts.
Carbonate of potassa	500 ,,
Sulphate of zinc	35 ,,
Chloride of copper	15 ,,
Water	5000 ,,

This solution may be made up in the same way as No. 1.

3. Bronzing solution.

This solution is the same as No. 1, excepting that 25 parts of chloride of tin are used instead of the sulphate of zinc.

4. Bronzing solution.

In this solution 12 parts of chloride of tin are employed instead of sulphate of zinc in the second brassing solution. This latter solution Salzede works at a temperature not exceeding 97° F.

The above solutions are to be worked with a brass anode, and with an active battery of two or more cells —Bunsen's battery being preferable to any other. The current of electricity employed in electro-brassing must have a brisk intensity—the quantity also being considerable.

The above solutions work very well at first, but they soon get out of order, owing to the irregular action of the cyanide upon the brass anodes, which readily attacks the copper, whilst the zinc frequently remains upon the surface of the anode in the form of a white paste. Hence the character of the solution soon becomes altered.

II. Brass Solution.

Acetate of copper	5 ounces.
Potassa	4½ pounds.
Sulphate of zinc	10 ounces.
Liquid ammonia	1 quart.
Cyanide of potassium	8 ounces.

Dissolve the acetate of copper, which should be previously pulverised, in half a gallon of water. Add 1 pint of the liquid ammonia, and then dissolve th

sulphate of zinc in 1 gallon of water, the temperature of which should be raised to about 180° F. When the zinc is dissolved, add the remaining pint of liquid ammonia to the solution, which should be well stirred immediately, in order to insure its perfect mixture with the sulphate of zinc.

Dissolve the potash in one gallon of water. Lastly, dissolve the cyanide of potassium in one gallon of hot water, and then mix the ingredients in the following order:—The solution of copper to be added to that of zinc; now add the solution of potash and cyanide. Stir the whole well together, and allow the mixture to digest for an hour or so, stirring occasionally. Add water to make altogether 8 gallons of solution.

The above solution must be worked with active battery-power and a brass anode—milled brass being preferable. The anode should be well cleaned before immersion. A little liquid ammonia may be added from time to time, and also a small portion of cyanide when the solution works slowly. The anode must be kept clean. I have also found it advantageous to add a little arsenious acid to the solution, which improved the character of the deposit, by rendering it brighter and less crystalline. The arsenious acid, however, does not at first appear to make much difference, but after a while the improvement becomes manifest. I generally apply the arsenic by mixing it with a strong solution of cyanide of potassium. About one ounce to the above solution will be sufficient at first, and the quantity may be increased by degrees.

III.

Acetate of copper	10 pounds.
,, *zinc*	1 pound.
,, *potassa*	10 pounds.

Dissolve the above substances in 5 gallons of hot water, and add cyanide until a precipitate is formed, which, upon adding more cyanide, becomes again dissolved. An excess of cyanide must be added. The patentees of this process (Messrs. Russell & Woolrich) use either a brass anode, or one of brass and another of copper at the same time.

IV. Bronze Solution of M. Brunel & Co.

Chloride of copper	1 pound.
Carbonate of potassa	25 pounds.
Sulphate of zinc	2 ,,
Nitrate of ammonia	12½ ,,

The chloride is to be dissolved in half a gallon of water; the carbonate of potassa in 6 gallons of water; the sulphate of zinc is to be dissolved in half a gallon of hot water. These three solutions are to be mixed together. Now add the nitrate of ammonia, and blend them all together by stirring well for a few minutes. Make about twenty gallons, by adding cold water.

This solution is to be worked in the same way as either of the above.

The above solution much resembles M. Salzede's process, and is prone to get out of order owing to the fact that the anode does not supply the solution with metal as fast as it is deprived of it by the articles coated. Unless the solvent employed will readily attack and dissolve the zinc of the anode, the solution must soon lose its proportion of this metal. The liquid ammonia used in one of the above processes seems to effect this more satisfactorily than an excess of cyanide. I have invariably found that in any of the above processes, the employment of a liberal amount of liquid ammonia has kept the anodes clean, and enabled the

solution to give better results in every respect. The white salt of zinc formed upon the surface of the anode is soluble in this menstruum, but sparingly so in cyanide of potassium. The ammonia and cyanide being in the solution in abundance, will keep the anode clean, without which the action soon ceases altogether.

V. Newton's Process consists in forming solutions for depositing alloys of copper, tin and zinc, and also, for depositing brass and bronze.

The patentee mixes chloride of zinc with chloride of ammonium, sodium, or potassium dissolved in water.

Acetate of zinc in solution mixed with acetate of ammonia, potassa, or soda.

In making up a brassing solution, Newton adds to either of the above solutions a proportion of a corresponding salt of copper—for instance, with the acetate of zinc he would unite the acetate of copper, and so on. He employs various other salts of zinc, with the corresponding copper salt, for the same purpose.

In making a bronzing solution Mr. Newton dissolves the double tartrate of copper and potassa, and double tartrate of the protoxide of tin and potassa, with or without the addition of caustic potassa. He deposits an alloy of zinc, tin and copper, by using a solution composed of the following substances:—double cyanide of copper and potassium; zincate of potassa and stannate of potassa; the zincate of potassa he forms by fusing oxide of zinc with caustic potassa, and the stannate of potassa either by fusing oxide of tin with caustic potassa, or by dissolving it in a solution of potassa.

For an electro-brassing solution the patentee employs *a solution composed* of a given quantity of oxide of *copper, dissolved* in an excess of cyanide of potassium;

oxide of zinc and a little liquid ammonia are then added, and the solution heated to 120° Fah., to 140° Fah. Water is then added, in sufficient quantity to allow the solution to contain about 3 oz. of the oxides to the gallon—*i. e.*, 2 of zinc to 1 of copper to form brass.

VI. Brassing Solutions.

I.

Cyanide of potassium	1 pound.
Carbonate of ammonia	1 ,,
Cyanide of copper	2 ounces.
,, zinc	1 ounce.

Dissolve in one gallon of water. The temperature to be raised to 150° Fah.

II.

Cyanide of potassium	1 pound.
Carbonate of ammonia	1 ,,

Dissolve in one gallon of water. Attach a large brass anode to the positive wire of a battery, and apply a small surface of cathode or negative electrode—say a strip of brass. The temperature should also be 150° Fah. By this arrangement the anode dissolves, supplying the solution with metal. The exact quantity which the solution has taken up may be ascertained by weighing the anode before and after immersion.

VII. Brunel gives another formula for a brassing solution :—

Carbonate of potassa	10 pounds.
Cyanide of potassium	1¼ pound.
Sulphate of zinc	1¼ ,,
Chloride of copper	10 ounces.
Water	12½ gallons.

The best way of making up the above solution is to *dissolve all the ingredients* in separate vessels ; then to

add to the sulphate of zinc and chloride of copper a portion of the solution of carbonate of potassa. Now add sufficient liquid ammonia to dissolve the respective precipitates at first formed, when the solution of cyanide and the remainder of the carbonate of potassa may be poured in, and water added to make altogether 12½ gallons. This solution must be worked with a large brass anode, and a brisk battery of two or more Bunsen's cells. The solution should stand for some hours before using it, when it may be separated from any sediment which may remain at the bottom of the vessel in which it is made.

The above solution will require to be replenished from time to time with a little cyanide of potassium and liquid ammonia, in order to keep the anode free from the white salt of zinc, which would otherwise form upon its surface. Arsenious acid improves this solution; and I have found that a little chloride of tin, dissolved in caustic potassa, tends to toughen the deposit.

Iron, lead, zinc, tin, and alloys of lead, &c., will not all receive an equally good coating of brass if placed in the bath at the same time. No two metals of different characters should be immersed together; and, indeed, different solutions should be employed for each metal or alloy.

Cast iron requires a solution containing a greater per-centage of metal than zinc or its alloys; whilst zinc will receive a good deposit when but little metal is in the bath. Lead also requires to be coated in a bath which is richer in the metals.

In immersing in the bath two different metals, as *cast-iron and zinc* for instance, the zinc would receive

the deposit at once, whilst the iron would not receive the smallest amount of deposit, and in striving to force the metal on the iron surface the operator may impair his solution. Even cast- and wrought-iron require to be coated in different baths. By observing this rule, the solutions are not so liable to get out of order.

Again, iron and zinc require different degrees of battery-power to effect a good deposit upon them. A battery which would coat zinc well would not cause the least deposit to take place upon cast-iron.

Electro-brassing Cast-iron work.—In preparing cast-iron work for the brassing bath, it will be necessary first to make up a "pickle" of the following:—

Sulphuric acid	1 pound.
Water	1 gallon.

The article is placed in the pickle, and allowed to remain until the oxide of iron has become loosened from the surface of the article, in other words, until a brush and sand will easily remove the oxide. If at any time the oxide is found to adhere firmly to the cast-iron surface, the pickling process must be continued until it yields readily to the brush.

When the work is very rusty, it may be first placed in a pickle composed of—

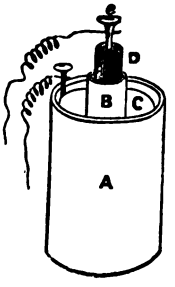
Hydrochloric acid	1 pound.
Water	1 gallon.

and any parts which may have a thick coating of rust may be cleaned by applying strong hydrochloric acid to the part, which readily dissolves the rust. It is better to *remove the rust,* as suggested, before immersing the *whole article in the* first pickle. Generally speaking,

from an hour to an hour and a half is sufficient time to remove the oxide of iron in the pickling bath.

As soon as the articles are pickled, they are to be well rinsed, and are then to be laid on a board, placed over a vessel of water, called the "cleaning-board," and are to be thoroughly cleaned with a hard brush, sand, and water until the oxide is completely removed. The article is then to be rinsed in clean water, and may be placed in a weak solution of potash or soda. It is now ready for the bath, in which it may be suspended by a stout copper wire connected with the negative electrode of the battery.

For most purposes I prefer using two cells of a Bunsen's battery, consisting each of a cylindrical stone jar A fitted with a cylinder of zinc, C, which must be well amalgamated and a copper wire attached to it. A porous cell B is placed in the centre, and a bar of carbon D is put into the cell, which is then filled with concentrated nitric acid. Into the outer cell is poured a solution of sulphuric acid, consisting of about 1 part of acid to 20 of water. A binding-screw is attached to the carbon, and a stout copper wire, which is to be soldered to a brass anode.



When the article has been immersed in the solution for a few minutes, a white foam will show itself at the point of the wire, in most instances, and frequently bubbles of gas will be seen to rise in various parts of the solution. In electro-brassing, generally, but little *deposition takes* place unless there is the evidence of *chemical action* alluded to.

As soon as the article has received the required coating—which, for ordinary purposes, may be accomplished in about two hours, with two cells of the battery just described, holding about four gallons in each jar—it is to be at once rinsed in hot water and then placed in hot saw-dust. For this purpose mahogany saw-dust answers very well. When thoroughly dry, if it is required to bronze it, the article should be rubbed over with a leather and a little powdered pumice or whitening, in order to brighten those surfaces which are to look bright when the work is complete. Instead of bronzing it, the article may be cleaned and lacquered. The bronzing process is described at page 37.

Electro-brassing Wrought Ironwork.—It is more easy to electro-brass wrought than cast ironwork, as it is less porous, and is in general much more smooth. The goods may be first pickled in the sulphuric acid pickle-bath, and then cleaned with a brush, sand, and water. The solution in which wrought ironwork is brassed need not contain quite so much metal as that for cast iron, and it generally does not require the exposure of so great a surface of anode.

When the goods are placed in the bath, if the deposit appears of too red a hue, rather more anode must be exposed; if, on the other hand, the work is pale, less of the anode should be immersed. The surface of anode will generally regulate the colour of the deposit. Wrought iron receives the deposit more readily than cast iron, consequently it need not remain in the bath quite so long as the latter.

Electro-brassing Articles of Zinc.—Goods of this description *should first* be placed for a quarter of an *hour or so in a pickle* consisting of:

Sulphuric acid	1 ounce.
Hydrochloric acid	2 ounces.
Water	1 gallon.

The articles may then be rinsed in clean cold water, and, being placed on the cleaning board, they should be scoured well with a hard brush, sand, and water. Zinc goods, if the battery and bath are in good working order, will receive the deposit immediately on being immersed in the bath; when the reverse is the case, however, either the solution is deficient in conducting power—in which case add fresh cyanide and liquid ammonia—the battery is weak, or the surface of anode must be increased. The goods, when sufficiently coated, are to be rinsed in hot water, and then placed in hot mahogany saw-dust; it is important that the articles should be well rinsed. This class of work may be bronzed or polished and lacquered.

Electro-brassing Lead and Pewter Articles.—Lead does not receive the deposit so favourably as zinc, but pewter receives it tolerably well. They may, however, be both coated in the same bath without harm. Lead should be pickled in a dilute solution of nitric acid, say a mixture containing about four ounces of nitric acid to the gallon of water. The same pickle will do for pewter work. The goods may remain in the pickle for half an hour, when they are to be well rinsed and scoured with sand as before; lastly, rinsing in clean water. A good surface of anode should be exposed, more especially when the articles are first put into the bath. If the battery power is not ample, lead is very apt to become coated *in parts*, owing to its being a very indifferent *conductor of the* current.

In brassing lead and pewter, it is advisable to raise

the temperature of the bath to about 90° Fahr., when this can be done conveniently. The same observation applies to coating tin with brass.

When a brassing solution has been worked for some time, it is liable to deposit either copper or zinc only—generally speaking the former. The principal cause of this is that the solution has not the power of dissolving the brass anode equally, the copper in the alloy being readily attacked by the cyanide and consequently entering the solution, whilst the zinc, being liable to be converted into an almost insoluble salt, either remains on the anode in the form of a white mass, or falls to the bottom of the bath, but a small portion of it entering the solution; consequently the latter, instead of depositing the yellow alloy, deposits only, or chiefly, copper. When the bath is thus found to work unfavourably, it will be necessary to add a little more concentrated solution of zinc; but sometimes I have found that the addition of a large quantity of liquid ammonia to the bath has dissolved a considerable portion of the zinc precipitate from the anode and from the bottom of the vessel, and thus the bath has become restored to its proper condition. When adding the liquid ammonia—which should be the strongest which is made—it is as well to add a little additional cyanide.

The bath may also be restored by separating the clear solution from the precipitate which has fallen to the bottom of the vessel, and by then treating the latter with liquid ammonia and cyanide, which will dissolve the greater portion of it. This is the best plan when it is practicable. The solution thus formed may be *added to the bulk* of the solution, which will then work *well again.* Therefore, whenever the anode assumes

the white appearance referred to, liquid ammonia or cyanide, or both, must be added, otherwise copper only will be deposited.

Sometimes the bath will become deprived of both zinc and copper, in consequence of the anode not keeping up the supply in the solution. When this is the case, a strong solution of brass should be added to the bath: in fact, a supply of concentrated brass solution should always be kept on hand to be thus employed in case of emergency, for the best solutions are apt to become deprived of metal after being worked a good deal.

Electro-deposition of Platinum.—A solution of platinum may be made by dissolving a piece of the metal in two parts of hydrochloric acid and one part nitric acid, over a sand bath. The acids must both be very strong, or the metal will not yield to their action. When the platinum is dissolved, the acid should be expelled in the same way as that recommended in forming the chloride of gold. A reddish mass will be obtained, which is the chloride of platinum. A little distilled water is now added to dissolve the chloride, into which put a small lump of cyanide, which will at first precipitate and then re-dissolve the platinum. The solution should have about five dwts. of metal to the quart. In working it, the solution should be warm. It is better, however, to filter before using the platinum solution, to remove the impurities with which the cyanide is contaminated.

The battery power employed for depositing platinum should be rather weak, or the metal will be thrown down in the form of a black powder, possessing but little resemblance to the metal itself.

As a platinum anode will not be acted upon by the *cyanide, the solution* will, of course, soon yield the metal

f which it was composed; therefore, it will be necessary, rom time to time, to add fresh chloride of platinum to eep it in working order. If it is desired to coat an rticle strongly with platinum, it will be necessary to eep on adding chloride of platinum to the solution very now and then while deposition is going on, until he object is accomplished. This of course renders the rocess of electro-platinising not only expensive but edious; and, for general purposes, impracticable. The yanide will hold but a small quantity of platinum in olution.

Palladium may be somewhat more readily deposited from its solution than platinum. The metal is to be dissolved in nitro-hydrochloric acid in the same way as above. The solution is next to be treated with cyanide, which will precipitate the metal, and finally redissolve it. The solution may be worked warm.

The palladium anode will be acted upon by the cyanide, consequently the operator may deposit the metal to any desirable extent. There is, however, but little importance attached to the deposition of this metal.

Lead.—A solution of lead for the purposes of electro-deposition, may be formed by dissolving the acetate or nitrate of lead in water. By employing the solution in a rather weak state, with moderate battery power, lead may be deposited with ease, but the deposit from these acid solutions is of a very indifferent quality. An alkaline solution may be made by precipitating the lead from either of the above solutions, either with soda, potassa, or ammonia, and then re-dissolving with cyanide, *but the solution* is only fit for experimental urposes.

Electro-deposition of Nickel.—The surprising progress which this branch of the electro-metallurgic art has made since the publication of former editions of this work, is due to several important improvements in the manufacture of the principal materials employed, and to the introduction of powerful and effective Dynamo-electric machines. The difficulty in obtaining pure nickel anodes of large surface for many years checked the progress of this useful art, whilst the slow and uncertain action of the ordinary battery rendered it ill-suited to the deposition of this peculiar metal on a large scale. Again, the manufacture of the double salts of nickel and ammonium was so imperfect, that constant failures attended the making up of baths from the nickel salts of commerce, even though high prices were paid for them.

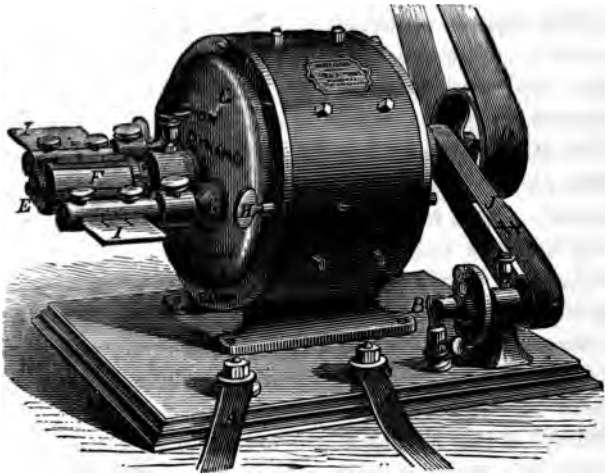
The time has now arrived, however, when it may be fairly stated that the art of nickel-plating has become, in proper hands, one of the most successful, and at the same time one of the most extensive branches of electro-deposition. For several years nickel-plating in this country had been principally confined to some three or four houses. Now, however, that the difficulties referred to have been overcome, the process has been most extensively adopted in London and throughout the kingdom, as also in many foreign countries. There is no doubt that the extensive application of nickel-plating in the United States acted as a stimulus to our own manufacturers who have steadily, though tardily, recognised in nickel a most useful coating for certain kinds of metal work. It is doubtful, however, whether nickel-plating would ever have held a really *high position* in the arts if the Dynamo-electric

machine had not been introduced. Before going further into our subject, it may be advisable to give the reader some information respecting this remarkable apparatus for generating electricity by motive power.

We may state that we have seen many of these machines in operation at some of the largest nickel and other electro-plating works in London and the Provinces, and the results obtained have been in the highest degree satisfactory. It was, in fact, at the author's suggestion that the first of these machines was tried and adopted by the Plating Company, Limited. In this instance, a single Dynamo-electric machine supplanted five large Wollaston batteries of some thirty-five or forty pairs of plates (zinc and copper). And when it is considered that the machine referred to is only about the size of an ordinary gas meter, and barely requires 1-horse power to give it the necessary motion, it will be at once seen that such a compact and effective substitute for the cumbrous and troublesome battery, is a great advance in the art of nickel-plating. Indeed, as we have said, it is doubtful if this branch of the art could ever have been extensively pursued with advantage on a large scale if battery power alone were available.

An important addition to our apparatus for generating electricity is Weston's Dynamo-electric machine (see engraving), the capabilities of which are very remarkable. The colour of the nickel deposit (provided the solutions are made with pure nickel salts) is nearly as white as silver; the required coating is obtained in about one-third of the time occupied by *ordinary batteries*, while the deposit is remarkably

even, smooth and bright. The only appreciative cost in working this machine is the steam power required to give it motion, about ¾ horse-power being sufficient for a medium machine, capable of depositing, it is stated, about 20 ounces of silver per hour. The wear-and-tear of the Dynamo-machine cannot be very great, as it only requires a speed of about 800 or 900 revolutions per minute to keep it in full action, and with



Weston's Dynamo-electric Machine.

proper attention to lubrication there appears but little friction. When we bear in mind the consumption of acids, zinc, &c., in the voltaic battery, and the loss of current from local action caused by imperfect amalgamation of zinc plates, and that for each ounce of metal deposited by the battery *its equivalent of zinc must be dissolved,* it will be apparent that the moderate quantity of fuel required to give ¾ horse-power (especially

f taken from a large engine used for other purposes) rill be far less costly than the consumption of material a the battery. In speaking of the "equivalents" of ıetals, without going deeply into the theory of Dalton re may remind the student that if 32 ounces of opper, 108 ounces of silver, or 28 ounces of nickel .re deposited by voltaic electricity, 32 ounces of zinc *nust have been* dissolved in each case, irrespective of he acid consumed; and if the zinc has been impro-perly amalgamated, or from any other cause the full *heoretical* amount of current is not obtained, it is likely that two or even three times the equivalent quantity of zinc may be dissolved in depositing the chemical equivalent of the other metals. In Dynamo-electricity there is no such uncertainty as this, since the electric current is dependent entirely upon motion for its development.

To give a detailed description of the Weston Dynamo-electric machine—and, indeed, the same remark applies to all other similar machines—would serve no useful purpose in a work of this kind, since it is obvious that any one desirous of investigating its merits, with a view to its adoption, would naturally obtain the fullest practical information from the manufacturers. We may state, however, that some of our principal electro-plating firms, and electro-typists, have adopted Dynamo-electric machines in preference to battery power, and with unquestionable advantage both in economy and rate of deposit per hour. For large operations Dynamo machines are indispensable.

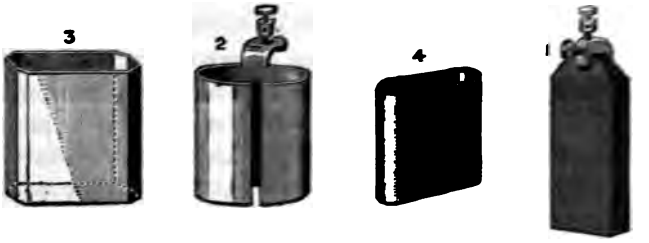
Magneto-electricity is also largely used for depositing metals, and with great success; but the compact-*ness, simplicity, and* energy of the Dynamo-electric

machines, together with the small amount of attention they require, gives them a decided advantage over their electrical competitors. In size, the Dynamo-machine is about equal to an ordinary gas-meter, and it seems surprising that so large an amount of current as it is capable of yielding can be obtained from so small a contrivance.

The improvements in electrical apparatus have lately been so considerable, and the exertions which are now being made at home and abroad towards further progress are so vast, that ere long we may hope to see the electric current employed for lighting and other purposes to an extent which has never before been reached. To give the reader some idea of the application of dynamo-electricity in America, in the deposition of metals, but more especially in electrotyping and nickel-plating, it is stated that there are upwards of two hundred firms in New York alone who have adopted dynamo-machines, and thus the arts of nickel-plating and electrotyping in the States have attained a perfection which has probably never been equalled before in any country. The substitution of dynamo-electricity for ordinary battery power is now being extensively recognised throughout the United Kingdom, and when the adoption of this source of power becomes fully developed, electro-deposition will doubtless progress to an extent far beyond any previous attainment in the history of the art. The author has been tempted thus far to dilate upon the relative advantages of the new system of producing electricity for electro-metallurgical operations, in order that both *the student* and the practical worker may be ac-*quainted with* the latest and most important feature

in connection with the deposition of metals from their solutions.

Nickel-plating on a small scale may be successfully carried on by means of the Bunsen battery (page 80). A very useful modification of this battery has been imported from the United States (see engraving). It consists of a pair of carbon plates, 1, united by a clamp with binding screw attached; an oval cylinder of stout sheet zinc, 2; a porous cell, 4, and a glass or stone-ware outer cell, 3. This convenient battery is capable of giving



a very powerful current, and is admirably suitable for nickel-plating small articles.

Nickel Solutions.—Although there are several salts of nickel from which the metal may be deposited by electricity, there are but two of these which have any practical value—namely the double sulphate of nickel and ammonia, and the double chloride of nickel and ammonium. These salts were first suggested by M. Boettger in 1843, and it is a remarkable fact that they have not yet been superseded. Mr. Adams of Boston, Massachusetts, taking advantage of Boettger's process, obtained a patent in 1869 for certain modifications of the ordinary way of making the double salts *of nickel, but as his* process is a very roundabout one

it would scarcely be applied by any one having a practical knowledge of chemical manipulation.

A very ingenious method of preparing the double salts of nickel and ammonia was patented by Mr. Unwin of Sheffield, in 1877, and since it presents some rather novel features, we give an extract from his specification. By this process, the salts of nickel and ammonia are thrown down in the form of a granular salt, readily soluble in water, and thus the tedious process of crystallisation may be avoided.

MR. UNWIN'S PROCESS.

"To effect the first object of my invention, I prepare a pure double sulphate of nickel and ammonia in the following manner:—I first prepare a pure double sulphate of nickel, by taking three parts of strong nitric acid (sp. gr. = about 1·400), one part of strong sulphuric acid (sp. gr. = about 1·840), and four parts of water, all by measure, mixing them cautiously, and about half-filling an open earthenware pan with the mixture. To every gallon of this mixed acid, I then add about two pounds of ordinary grain or cube nickel, and I heat the liquid by a sand-bath or other suitable means. If during the process of solution the action becomes inconveniently violent, I moderate it by the addition of a little cold water. If the nickel entirely dissolves (except a small quantity of light black matter), I add more of it, in small portions at a time, and continue the addition at intervals until it is in excess. When the production of red fumes has nearly, or entirely, ceased, or when the *liquid becomes* thick and pasty from the separation of *solid sulphate of* nickel, I add a moderate quantity of

hot water, and boil and filter the solution; the deep green liquid so obtained is a strong solution of sulphate of nickel. If, from the circumstances of its production, I consider that it requires purification, I concentrate the solution by evaporation, until on cooling it yields a considerable per-centage of crystals of sulphate of nickel; these crystals I collect, wash with a little cold water, and re-dissolve in a moderate quantity of hot water, filtering again, if necessary. When cold the liquid is ready for further treatment. I do not make any claim to originality in the above described method of preparing the sulphate of nickel by itself, as it is nearly identical with that described by me in the specification of letters patent granted to me, and bearing date December 21st, 1871, No. 3,459; but I do claim the method of obtaining a pure double sulphate of nickel and ammonia, to be presently described, and in which the sulphate of nickel prepared as above is employed.

"I next prepare a strong solution of sulphate of ammonia, by dissolving the salt in hot water, in the proportion of about four pounds of the salt to each gallon of water, and then filter the liquid, if necessary, and allow it to become cold. I then obtain the pure double sulphate of nickel and ammonia, by adding the above described solution of sulphate of ammonia, to that of the sulphate of nickel, obtained as hereinabove described; but I do not stop the addition of the solution of sulphate of ammonia, when sufficient has added to combine with all the sulphate of nickel present, but I continue to add it in large excess. I do this because I have discovered that the double sulphate *of nickel and ammonia* is far less soluble in the solution

of sulphate of ammonia, than in pure water, so that it is precipitated from its solution in water on adding sulphate of ammonia. I therefore continue adding the solution of sulphate of ammonia, continuously stirring until the liquid loses nearly all its colour, by which time the double sulphate of nickel and ammonia will have been precipitated as a light-blue crystalline powder, which readily settles to the bottom of the vessel. I then pour off the liquid from the crystalline precipitate of double sulphate of nickel and ammonia, and wash the latter quickly with a strong, cold solution of sulphate of ammonia, as often as I consider necessary for its sufficient purification; but I do not throw away this liquid after use, but employ it at my discretion for combining with fresh sulphate of nickel, instead of dissolving a further amount of sulphate of ammonia. If I desire to make a further purification of the double sulphate of nickel and ammonia, I make a strong solution of it in distilled water, and add to the liquid a strong solution of sulphate of ammonia, by which means the double sulphate is precipitated in a very pure condition, and is separated from the liquid by filtration or by other convenient means, and then dried, or used direct as may be desired: the liquid strained away can be employed, instead of fresh solution of sulphate of ammonia, for combining with more sulphate of nickel, or for washing the precipitate of the double sulphate."

The double sulphate of nickel and ammonia and the double chloride of nickel and ammonium may also be made by what is termed "the battery process." A plate of pure nickel is suspended in a dilute solution of *sulphuric or* hydrochloric acid (say, one part acid to *ten parts water*). The nickel plate is to be connected

by a copper wire to the positive pole of the battery (Bunsen's, by preference), or dynamo-machine, and the negative pole placed in contact with a few pieces of clean sheet-copper, previously put into a porous cell. A sufficient quantity of the dilute acid is to be poured into the porous cell, to the level of the acid solution in the larger vessel, and the cell placed in the dissolving bath. In a few hours the acid will have combined with its equivalent of nickel. By weighing the nickel plate before and after immersion, the amount of nickel in solution may be estimated. After removing the porous cell, &c., liquid ammonia is to be added to the solution until it becomes neutral to litmus-paper. To each ounce of sulphate or chloride of nickel in solution, one ounce of sulphate or chloride of ammonium is to be added. Unless the nickel employed in the above operation be pure, the resulting solution will not yield good results. It is safer, therefore, *before* adding the ammonia (that is while the solution is acid) to take a small quantity of the nickel solution, and pass a stream of sulphide of hydrogen through it, which will throw down, in the form of a black precipitate, any copper or iron that may be present. Sulphide of hydrogen does not precipitate nickel from an *acid* solution. As it is now quite possible to obtain pure nickel plates (or anodes), the operator may not be troubled by the presence of other metals.

A very simple way of making a solution of nickel for ordinary purposes, and which, with care, will give very good results, is the following:—Take, say, 2 ounces of pure nickel, dissolve in hydrochloric acid, taking care not to have an excess. A gentle heat will assist the operation. When dissolved, dilute the solution

with 1 quart of cold water. Now add ammonia, gradually, until the solution is quite neutral to test-paper. Next, dissolve 1 ounce of sal-ammoniac (chloride of ammonium) in water, and mix this with the former solution. Lastly, evaporate and crystallize slowly.

The double sulphate of nickel and ammonia may be readily formed by dissolving oxide of nickel in dilute sulphuric acid; the solution is then to be neutralised with ammonia, and crystallized. To each ounce of the dry crystals add 1 ounce of sulphate of ammonia, then dissolve and recrystallize. Cube or grain nickel may also be dissolved in a mixture composed of 1 part sulphuric acid and 2 parts water, to which add a little nitric acid, applying moderate heat. The solution should be set aside to crystallize, and sulphate of ammonia added in the same proportions as before. The salts are then to be dissolved, the solution filtered, and evaporated to crystallization.

Both of these solutions should be filtered before using, or allowed to stand until perfectly clear, when they may be carefully decanted. One Bunsen battery will be found sufficient for coating small articles.

In making up a bath with either of the above nickel salts, 12 ounces of the crystallized double salt are to be dissolved in each gallon of water, when the solution will have a specific gravity of about 1·50 (water being 1,000).

Of the two salts (double sulphate and double chloride of nickel and ammonium), we much prefer the former for all practical purposes, although we have seen excellent results obtained with the latter salts. In *practice, on a large scale,* the double sulphate of nickel *and ammonia is* most universally adopted. A combi-

nation of both the double salts has been employed by some persons with good results.

After the work has been cleaned by the processes hereafter given, it is generally the practice, in the case of brass-work, to dip it for a moment in a weak solution of cyanide of potassium, and then to rinse well. The object of this is to remove any slight trace of oxidation that might have formed during the process of cleaning, and since this slight film of oxide, as we have explained, would not become dissolved in a nickel solution, the "cyanide dip," as it is called, may be used with advantage. Steel and iron work, however, require to be dipped (after cleaning) into a dilute hydrochloric acid pickle,—say, half a pound of acid to each gallon of water. The hydrochloric acid will readily remove any trace of oxide from the surface of steel or iron, and after again well rinsing, the articles should be placed in the bath without delay.

Cast-iron work, before being nickel-plated, requires to be first placed in the potash bath, to remove grease. It is then to be well rinsed in cold water, and afterwards immersed in a pickle of sulphuric acid (half-a-pound of acid to each gallon of water), until the black scale usually found upon its surface becomes readily removable by brushing with sand and water. Some persons use powdered pumice for this purpose, but the author prefers sand, for the reason that this substance, besides being cheaper than pumice, leaves the surface of the work brighter; and since cast-iron work is generally required to be left *dead* (that is, not polished) it presents an agreeably bright appearance, when plated, which the pumice-prepared work does not equal. *In cast-iron articles*, the existence of numerous

"sand-holes" is frequently a source of great trouble to the nickel-plater, inasmuch as it is impossible to obtain a deposit of nickel upon any surface which is not absolutely free from foreign matter. Again, nickel has such a great objection to turning a corner, under any circumstances, that unless the sand-holes are perfectly clean, this metal will not become deposited even in the most trifling hollows. It is well, therefore, in order to obtain a deposit of nickel in the crevices referred to, to ascertain that they are quite free from non-conducting matter, which may be done by means of a sharp steel point, or the work may be brushed with the steel wire brushes employed for this and similar purposes, and this generally has the effect of rendering slight hollows free from objectionable matter. It is a good plan, previous to nickel-plating cast-iron, to give it a moderate coating of copper in the cyanide-of-copper bath, which not only enables the operator to ascertain if the work is perfectly clean, but also to ensure a successful deposit of nickel, the superior conductibility of copper greatly aiding the nickel coating upon cast-iron work. Indeed, both for steel and iron, as also Britannia metal and pewter goods, a previous deposit of copper from an alkaline solution presents many advantages; and as the operation of coppering occupies only a few minutes in a hot solution, and but a short time in a cold one, the slight extra trouble is scarcely worth consideration, as compared with the advantages obtained.

The perfect cleansing of the work to be nickel-plated is of more importance in the electro-deposition of this *metal than in* any other branch of the art, and for *this reason* :—In gilding, plating, bronzing, &c., the

solutions are formed with a highly caustic alkaline salt, the cyanide of potassium, which has the power of rendering soluble any slight trace of greasy matter that might be imparted to the work by the hands, or any such matter as may have been accidentally left upon it by careless cleaning. In all cases, it is of the utmost importance that the work should be absolutely chemically clean before immersion in the bath; but although, in the solutions named, a trifling deficiency of cleaning *may not* be fatal to the operation of gilding, &c., in nickel-plating the result would surely be stripping or peeling off of the deposited metal, wherever the least particle of foreign matter was present. The reason why articles to be nickel-plated require such delicate and careful preparation is that the solution of nickel is composed of salts which have no caustic property whatever, and therefore would not remove even the faintest trace of greasy matter from the surface of the work. Again, the cyanide of potassium is a powerful solvent of metallic oxides, and the trifling film of oxide which is apt to form upon the surface of brass, German silver, copper, or steel articles (if they have been exposed to the air for even a few moments after they have been cleaned) before immersion in the bath, would readily become dissolved the instant after immersion. This would not be the case in a nickel solution, however, since the salts of nickel and ammonia (being neutral) would have no solvent effect upon the oxidised surface, no matter how slight the film of oxide might be; and since a layer of oxide *between the article and the deposited metal* would prevent their close adhesion, the existence of such a film would *undoubtedly cause* the work to "strip," in the after

process of polishing, if not before. These considerations being borne in mind, we will now endeavour to explain the methods of preparing the work for the nickel bath which have been found most successful in practice on a large scale.

Preparation of work for Nickel-plating.—All the work to be nickel-plated must be first immersed in a boiling solution of caustic potash—American potash is generally used for this purpose—which is made by dissolving about half-a-pound of potash in each gallon of water. After being in use some time, this alkali loses its caustic property, in which case an addition of the salt must be made, otherwise the bath will fail to perform its proper function, that of removing any greasy matter, such as oil used in the process of polishing, &c. When the potash bath is newly made, immersion in the boiling solution for a few minutes only will be sufficient. As the bath becomes weaker by use, however, a longer immersion will be necessary. In the case of steel, iron, brass, and copper articles, they may be allowed to remain in the potash until required to be pumice-brushed for the nickel bath; but on no account should tin, Britannia metal, or pewter-soldered articles be allowed to remain in the potash solution for more than a few minutes, since this caustic alkali acts upon, and freely dissolves tin. Brass and copper articles should not be suspended by a metal rod in the potash bath at the same time as steel and iron work, in case, at any time, tin or pewter articles may have been immersed in the same bath, since the alkali would have dissolved a certain portion of the tin and this would become deposited upon the articles by the galvanic action set up by the two

opposite metals in solution. Cast-iron work, owing to its porous character, requires a longer immersion than any other metal.

Since all metals which have to be nickel-plated require a somewhat different treatment in preparing them for the depositing bath, we will consider each class of articles separately; but before doing so, it will be necessary to call attention to another important feature in the preparation of work to be nickeled.

The extreme hardness of nickel, as compared with silver and gold, renders it almost impracticable to apply the process of burnishing; it is therefore the practice to polish all kinds of nickel-plated work. In order, however, to render the after process of "finishing" more easily effected, the system adopted is to impart to the work a highly polished surface, *before*, as well as after plating. This final operation of finishing is conducted by skilled workmen, who, having a thorough knowledge of silver polishing, have acquired the more difficult art of polishing nickel. A smooth surface is first obtained by submitting the articles to the action of revolving buffs, made of the tanned skin of the walrus, bull-neck leather, &c., and finely-sifted sand. Trent sand, and "glass-cutter's sand" are generally employed for this purpose, owing to their power of rendering the work smooth without cutting too severely. After the work has been well "sanded," as it is termed, it is removed to another polishing spindle and again buffed with finely powdered and sifted unslacked lime. The lime best suited to this purpose, and also for the after processes of finishing, is obtained from the *neighbourhood* of Sheffield. It should be *kept in jars, or* other convenient vessels, carefully

covered to exclude air, and powdered in small quantities as required for use. Steel and iron work, if very rough, are rendered smooth by an emery-wheel, or a buff charged with emery and oil, before being polished in the manner before mentioned.

Brass articles, after being polished require to be immersed for a short time in the potash bath; they are then to be dipped for a moment in a moderately strong solution of cyanide of potassium, and after well rinsing are brushed over with finely powdered pumice and water, a moderately hard brush being used for the purpose. In place of the powdered pumice alone, an equal proportion of rotten-stone and pumice may be used, or finely-powdered and sifted bath-brick. After the work has been well brushed all over, it is to be thoroughly rinsed, again dipped in the cyanide bath, rinsed, and at once placed in the nickel-bath, where it should remain undisturbed until the required coating is obtained. As it is of the greatest importance, however, that the article should receive the deposit *almost immediately* after immersion, it may be lifted partially out of the bath for an instant, in order to see whether deposition has begun. It is very important that the work should be "struck" as it is termed, or receive its first layer of metal immediately after immersion.

In cleaning the work (so as to avoid contact with the hands), it is a common practice to hold the article with a piece of wet rag, kept for the purpose, while applying the brush and pumice. If the fingers are repeatedly dipped in pumice-powder, the rag may be *dispensed with*. The hands must not be allowed to come *in contact with* the work after being well scoured.

When the solution is in good order, and is kept free from dust and the disturbance of the sediment which sometimes forms at the bottom of the bath, the deposition of nickel will be perfectly smooth, and the work will require but little labour to give it the exquisitely beautiful polish of which it is susceptible. If, on the other hand, the above conditions are reversed, a roughness of deposit will show itself upon those upper surfaces upon which the objectionable particles have fallen, and this roughness will give additional trouble to the polisher. In cases where impure anodes are employed, it is of still greater importance not to disturb the sediment lying at the bottom of the bath. Anodes containing iron cause a yellow deposit to be formed which is exceedingly troublesome, since it not only attaches to the surface of the anodes, but also becomes deposited in a mass at the bottom of the bath. The slightest disturbance of this fine precipitate, will render it necessary to let the bath rest for at least 24 hours before using it. Thus, when an article falls from the suspending rod or slinging wire, for instance, in searching for it the iron deposit at the bottom of the bath is disturbed, and permeates the whole solution, rendering it absolutely necessary to let it repose until the solution is clear again.

Owing to the inferior conductibility of nickel solutions, as compared with those of silver and gold, it is necessary to place anodes on each side of, and directly opposite the article to be coated, otherwise a partial deposit only will take place. Again, from the same cause, namely, the indifferent conducting power of the solution, nickel has a strong objection to "turning the *corner," as we have* said. The deposit will take place

freely enough, if the electric current is vigorous, upon flat surfaces or projections, but for concavities, fissures, and hollows of all kinds, it has the utmost contempt, so to speak. This peculiarly amiable quality is highly manifest in coating cast-iron, in which large sand-holes and other flaws are common, and the only way to humour the nickel in such cases is to first coat the iron with a metal of superior conducting power (copper, for instance), which, acting as a sort of "go-between" or pacificator, will bring about the desired union, a perfect coating of nickel upon the inferior metal, iron.

Although it is advisable, in all cases where the price will admit of it, to deposit a good coating of nickel upon the work, it is found impracticable to go beyond a certain point; and if this be exceeded, the deposit has a tendency to crack and peel off the work in large flakes. In some cases, this will take place without the slightest touch. Indeed, it appears that on certain surfaces (unless the deposition be very gradual), there is a limit which must not be exceeded, or stripping will follow most certainly. A very moderately thick coating of nickel, however, owing to its extreme hardness, will last for many years, with ordinary care.

It is very important in nickel-plating that the "slinging-wires," as they are termed, should be of a gauge to suit the class of work to be coated. It is frequently the practice—the result of ignorance—to neglect this important detail, but when we consider the marvellous variety of objects which have to be nickel-plated nowadays, in sizes ranging from a small *split ring* to a cast-iron plug exposing a superficial surface of six or eight feet, it will be at once apparent

that a slinging-wire which would be suitable to the former would be quite unfit for use in the latter case. It is not a question of sustaining power alone, for it is self-evident that a thin wire of, say, 32-gauge would not support, when attached to the conducting-rod, a cast-iron article weighing half-a-hundredweight. It is therefore a question of conducting power, and it will be readily understood that while small articles, such as screws, split-rings, &c., require but a very thin wire to convey the current, articles of larger dimensions will need a much stouter wire.

Again, the difference of conductivity in the metals to be coated is of much consideration in nickel-plating, for whereas a steel, brass, or copper article would become readily "struck" (that is, receive an immediate coating of nickel), even if suspended from the conducting-rod by a thin wire, articles of lead, Britannia metal, pewter, or even cast iron would not receive the deposit so readily. The thickness of the slinging-wires, therefore, should be regulated according to the nature and dimensions of the article to be plated.

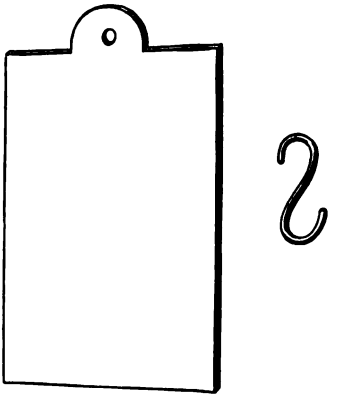
After the slinging-wires have been used once or twice (especially when a good, stout deposit has been given to the work), the crystalline nickel deposit upon the unprepared surface of the wire will render it very brittle, the deposited metal forming, as it were, a tubular coating upon the wire, which is very easily broken. Thus wires which have been employed several times for the purpose of suspending articles from the conducting-rod become totally unfit for use. It is better not to use the slinging-wires more than twice in nickel-plating; and these may be rendered useful *for future operations* by first stripping the nickel from

their surface, and then annealing them. A useful stripping acid suitable for nickel may be made with 2 parts nitric acid, 1 part sulphuric acid, 4 parts water, to which a little nitrate of potash may be added.

Nickel solutions being employed in a highly concentrated state (unlike gold and silver solutions), it will be noticed after working a bath a short time, especially in a warm atmosphere, that the green salts of nickel and ammonia begin to crystallise upon the upper surfaces of the anodes, and on the interior of the tank or depositing vessel. When this is observed (the original *waterline* being noticed), it will be necessary to add sufficient water to make up the solution to its original height. Some allowance, however, must be made for the quantity of solution removed from the bath from time to time by the work taken out of it; and in order to keep the solution up to the normal strength and the original height in the tank, it will be advisable to add fresh crystals of the double salts of nickel and ammonia. In doing this, however, it will be best to ascertain the specific gravity, and only to add sufficient crystals to bring the solution up to the standard (if the double sulphates of nickel and ammonia are used) of about 1·50 by the hydrometer. When the dynamo-electric machine is employed, it is not necessary to have the solution quite so strong as when ordinary battery power is used; indeed when the double chlorides of nickel and ammonium are employed, a much weaker solution than is required by the battery will give very good results. It must not be understood that we give any preference to the latter *salts, for we are of* opinion that for all purposes the *double sulphates* yield the best and most uniform

of which the metal is capable, as far as our
knowledge extends.

connections between the nickel anodes and
ting rods is, of course, of great importance, and
er simple this point may appear to the silver-
, it must not be overlooked in nickel-plating.
is a very infusible metal, and exceedingly
to run into the form of plates or anodes, and
e are generally, especially for large operations,
iderable weight, it
custom to drill a
about ¼ inch in
er, at the upper end
anodes (see illus-
, through which a
pper S-hook is or-
passed, the other
the hook resting
ie conducting rod.
unfrequently hap-
owever, that this
ion proves a very
ct one, from seve-



ies, amongst which may be mentioned the crys-
on of the nickel salts within the orifice through
he supporting hook is passed. In a bath fur-
with twenty-four nickel anodes, each about 7 in.
n., and nearly one inch in thickness, the author
ed to obtain a spark, when applying the nega-
e, from several—probably half-a-dozen—of the
; whilst from the remainder a spark was readily
d, *with the* exception of one or two, which gave
le evidence of the circuit being completed. It

at once occurred to him to secure a good connection between the suspending hooks and the anodes by means of soldering. The plan adopted was as follows :—The holes were cleaned by a rat-tail file; the hooks were dipped into the ordinary dipping acid (sulphuric and nitric acid) for an instant, and rinsed. One end of each hook was then moistened with chloride of zinc, and immediately plunged into a ladle containing molten tin. The tinned hook was next inserted into the hole in the anode, and a gentle tap with a hammer fixed it in its place. The anode being laid flat on a bench, with a pad of rag beneath the hole, the next thing to do was to pour molten tin or pewter solder into the hole, and afterwards to apply a heated soldering iron. When subsequently, and upon several occasions, adopting this method of improving, or rather securing a perfect connection between the copper support and the anode, it was found better to make the end of the anode to be soldered sufficiently hot to prevent it from chilling the solder. Before pouring the solder, however, the aperture in the anode should be brushed over with the chloride of zinc solution. The advantage of thus ensuring a perfect connection will be readily understood, especially when it is borne in mind, that the inferior conductibility of nickel and nickel solutions as compared with gold, silver and copper, offers a resistance to the electric current, which should not be increased by imperfect connections. Although these observations are chiefly directed to those who carry on the operation of nickel-plating on a large scale, they may not be found unacceptable even to the student in *the art.*

In all kinds of electro-deposition, upon a scale of

any magnitude, one of the greatest difficulties is to obtain a solution vat or tank which will hold, without leakage, or contamination of the materials of which the solution is composed, any given solution. Slate tanks, put together with india-rubber, or gutta-percha, or even with fused sulphur, and various cements, have been used, and for some purposes have proved tolerably satisfactory; but the absorption and eventual crystallization of chemical salts within the interstices of this material have invariably ended in its disintegration, or gradual crumbling away. Vats or tanks made of wood, be they never so cunningly put together, being tongued, bolted and screwed with the utmost care, invariably leak. Disappointment, delay, and loss of material have been so great in this respect, that we would certainly dissuade any intending nickel-plater from putting his faith in wood alone. It is a good plan to have the tank made of ordinary pine, well bolted and screwed for strength; it should then be lined with thin sheet-lead, carefully and effectually "burned," so as to be thoroughly water-tight. After ascertaining beyond doubt that the leaden lining will hold water, it should next have a lining of match-boarding, properly and carefully placed, without nail or screw, this wooden lining being bound together and held in position by an upper frame of wood. A plan which has been adopted of lining wooden tanks with lead, and then pitching them throughout, has proved a very unsuccessful one, and for several reasons: pitch does not firmly adhere to metal, when constantly in contact with water; the frequent variations of temperature *between* the summer and winter months, and *the difference* between the heat-conducting power of

lead and water, cause the separation of the pitch coating from the metallic surface. Again, in a lead-lined and pitched tank, if the anodes press close to the sides of the vessel, the weight of the anodes frequently causes the copper hooks which support them to become imbedded in the pitch, until they eventually come in contact with the leaden lining; and as the fugitive coating of pitch gives way (often in large flakes, which rise to the surface of the solution), the metallic lining, being in connection with the anodes, actually becomes a positive electrode, thereby endangering the equilibrium of the solution. In the case alluded to, the electric spark was obtainable from every part of the leaden lining of the tank or rather tanks, by which much of the power was lost; and this need not be wondered at, when we consider that the anodes weighed nearly a quarter of a hundredweight each, and were placed so close to the sides of the tanks that during the hot summer months it was no troublesome task for the supporting-hooks to imbed themselves comfortably in the softened pitch, and thus place themselves in direct contact with the metal lining.

In small operations, where only a few gallons of nickel solution are required, the best material to adopt is the ordinary stoneware, such as may be obtained from the Lambeth potteries. This material is well suited for most chemical operations, inasmuch as it is neither affected by acids, alkalies, nor alkaline salts, unless there be an accidental flaw in the vessel, in which case mischief may occur at any time. In selecting stoneware for nickel-plating or other purposes, it is advisable to well examine and sound the vessels to be selected, before purchasing them.

It is well known to electro-metallurgists that metals deposited by electricity do not adhere so firmly to their kind as to other metals. Thus gold will adhere more tenaciously to silver, copper, or brass than it will to gold or to a gilt surface, and silver will attach itself more closely to copper or brass than to a silver-plated surface. Knowing this to be the case, it is the practice to remove, by "stripping" or polishing the silver from old plated articles before electro-plating them. If this were not done, the deposited coating would in all probability "strip," as it termed, when the burnisher was applied to it,—that is, the newly deposited metal would peel off the underlying silver. It must be understood that these remarks apply to cases in which a good, stout deposit of silver is required, for, of course, a mere film would not present any remarkable peculiarity.

In strengthening electrotypes, when the object is to deposit as speedily as possible a stout coating of copper upon the original "shell," it is easy to recognise the second or third layer of metal, resulting from increased battery power, temporary exposure to the atmosphere, or other disturbance of the original condition. But in no case does the non-adhesion of a metal upon its kind show itself more forcibly than in that of nickel. For example, if an article has been coated with this metal, (even lightly), and after being properly brushed with powdered pumice and water it receives a further deposit in the bath, it is more than probable that the second layer will separate from the first, either under the hands of the finisher, or (if the deposit be a moderately stout one) without coming in contact with any substance whatever. *It is* not an uncommon circumstance, in *nickel plating* under unfavourable conditions, to

the deposited metal rise up in flakes, from one or more parts of an article (especially on steel surfaces), without even having been touched by the hand. And although this peculiar phenomenon will show itself upon new work occasionally, it is more frequent in work which has been previously plated with nickel.

The Americans adopt the system of suspending a piece of stout wire from either end of the negative suspending rod, and this is always allowed to remain in the solution, so as to divert the current when small articles are first placed in the solution, and thus to prevent them from "burning," as they call it. This wire is called a "stop."

In one case where we have seen this plan adopted, a rod of brass, which had been suspended in the bath for some considerable time, became coated with nickel in a crystalline form the deposited metal being built up in a series of crystalline nodules, of great depth and solidity, the lower portion of the rod (which was about $\frac{1}{4}$ inch in thickness) having received a deposit of about 1 in. in diameter and which, tapering upward, to the length of about 15 in., exhibited crystals of the metal throughout its whole length, terminating in a deposit of about $\frac{1}{16}$ of an inch. A piece of brass *tubing*, however, which had been used for the same purpose, exhibited a very remarkable difference as to the character of the deposit. After having received the first coating of metal (while the bath was full of work) it was destined to remain in solution while the second batch of articles was being prepared, during which period the dynamo-electric machine was stopped. *When the machine* was again put in motion, the tube *received a second* deposit, and so on from day to day,

until it finally presented a very peculiar appearance. Instead of being coated with a solid body of metal in the crystalline form referred to, it exhibited numerous laminæ, more or less detached from each other; and when several of these layers had become partially attached, they broke away—curling outward—from the underlying coatings, presenting a very rugged and irregular appearance. On examining these deposits, it was found that the various layers of nickel had no adhesion whatever, and that they were easily separable with the point of a penknife. In fact, the operation was not unlike that of separating the laminæ of mica.

If, therefore, as we have endeavoured to show, metals—but more especially nickel—do not readily adhere to their kind when deposited by the electric current, we must avail ourselves of the best means to avoid the stripping or peeling off of the electro deposit from the underlying metal.

When an article has to be re-nickeled it is best, in the first instance, to remove the old coating by dissolving it from the surface, taking care, as far as possible, not to affect the metal of which the article is made. Suppose, for example, a piece of brass work has to be re-nickeled, the first thing to do is to prepare a stripping acid which will readily remove the nickel, without impairing the brass in any appreciable degree. For this purpose, a mixture of sulphuric and nitric acids may be used, in various proportions, but probably the following will be found most useful for general purposes:—Take, say, 4 lbs. strong sulphuric acid, 1 lb. nitric acid, and about one pint of cold water, and mix together in a stone jar. The *water should* be added gradually. Nickel-plated

articles may be stripped in this solution by immersing them in it for a few moments. If the coating is very thick, several minutes will elapse before the metal becomes entirely removed. The solution may be gently warmed before using, but this is not absolutely necessary. The operation of stripping should be conducted in the open air if possible, or near a fire-place, so that the acid fumes may escape through the chimney. The articles to be stripped should be attached to a copper wire, and taken from the solution from time to time, so as to observe whether the metal has been removed. The articles must not be allowed to remain in the stripping acid one moment longer than is necessary to dissolve the nickel from the surface of the article. Lightly coated work may be stripped in less than half a minute. When the stripping of brass work has been properly conducted, a smooth, bright surface is presented, showing but little evidence of the action of the acid upon the article itself. It is hardly necessary to state that the acid fumes are deleterious, and should not be inhaled by the operator. Nickel may be stripped by means of the battery, that is to say, by attaching the articles to the positive electrodes, (employing them as an anode); but a separate solution should be used for this purpose, as it may acquire a trace of copper from the brass work, which would impair the ordinary solution-bath. When the battery is used for stripping nickel-plated work, it is a good plan to employ a solution of dilute sulphuric acid for the purpose, which will dissolve the nickel without affecting the brass to any appreciable extent. Where the dynamo-electric machine is employed, the current may be advantageously *used for stripping* old work, as the operation can be

effected in a short time by this powerful machine, and thus the annoyance of acid fumes may be avoided. The energy of a dynamo-electric machine would enable the user to strip a large quantity of old plated work in a very short space of time. Articles which have been stripped require to be repolished before being plated a second time, and it is very important that none of the old nickel coating should be left upon the work, otherwise it will surely strip when being finished.

Cast-brass work, when it presents numerous and deep sand-holes, should be well dipped in the dipping acid before being polished, in order to thoroughly clean these objectionable cavities; and the polishing should be pushed to an extent sufficient to obliterate the smaller sand-holes, if possible, as this class of work looks very unsightly, when plated and finished, if pitted all over with minute hollows. The larger sand-holes cannot, without considerable labour, be obliterated; indeed, it not unfrequently happens that in endeavouring to work out such cavities, they become enlarged, as they frequently extend deep into the body of the metal. An experienced hand knows how far he dare go in polishing work of this awkward character.

A very important and troublesome defect in the deposition of nickel will sometimes present itself, and must receive immediate attention when observed. Certain dark streaks will sometimes be found to start from a given spot, and extend occasionally to several inches in length. Reflectors, with rivets upon their faces, will generally give some trouble from this cause, even when the utmost care has been bestowed upon the preparation before plating. It will be found that the dark streak referred to starts from each rivet,

extending downward to the outer edge of the reflector. The cause of the defect is dirt, or grease, beneath the rivet-head, which, when the article is in solution, gradually oozes out, and by its gravity, slowly traverses the face of the reflector while deposition is going on. At the spot where the particles of dirt have been slowly travelling, there is little or no deposit of metal, the continual flow of minute particles of foreign matter over the spots indicated having prevented the deposition of metal at such parts. As these defects will show themselves at an early stage of the process, the article should be examined, after having been in the bath a few minutes, and if the streaks appear, it must be again well brushed with powdered pumice, rinsed, and returned to the bath. It would be fatal to the success of the operation if these precautions were not taken, as the parts where the streaks had occurred would show the underlying metal the moment after the polishing-buff was applied, even though the rest of the article had received a substantial coating of nickel. Although defects of this character frequently show themselves in silver-plating, they are not so serious as in plating with nickel; and for the reason that the cyanide of potassium in the silver solution would have a tendency to saponify any trifling greasy matter, while the nickel solution would have no such effect upon it.

To regulate, or govern the amount of electric current generated by the dynamo-electric machine, or by powerful batteries, the "resistance coil" (see engraving) is indispensable. This simple contrivance consists of a mahogany or cedar board, about 14 in. × 10 in., upon which a coil of thin brass or German silver wire *is stretched by* means of brass pins. By moving the

key to S (strong) the full current passes into the vat. If the key, however, be moved from peg to peg towards the right, the current is resisted, gradually, until, on reaching W (weak) the amount of current entering the vat is reduced to a minimum. In starting this instrument the key should be placed at W, and as the bath is being filled with work, it should be gradually shifted, one peg at a time, in the direction of S. When carefully and judiciously employed the resistance coil enables us to control the current to the fullest extent—a most important advantage in large operations. Where the dynamo-electric machine is adopted, this means of governing the current is indispensable. Although there are many forms of this instrument, all more or less useful, we are inclined to think that the one represented in the woodcut is about the best, especially if the wires, half-way from S to centre of the coil, are of German silver, and the remainder of the wire brass, united to the former by hard solder.

It is very essential that the wires of the coil should be placed at some distance from the board, otherwise, when the full amount of resistance is affected, by placing the key at S, the wires frequently become red-hot, and the board is liable to be charred, as we have frequently known to be the case. The brass pins for supporting the wire should be long enough to keep the wires at least three-quarters of an inch from the surface

of the wooden board. Should the wires become dislodged at any time, so as to approach the board too closely, they should be at once readjusted and placed close up to the head of each pin.

Tin.—A very good tinning solution may be made by first dissolving granulated tin in hydrochloric acid, taking care to have an excess of the metal. This should be done over a sand-bath and the acid fumes allowed to escape through the flue. When the fumes cease to be given off, the vessel should be set aside until quite cold, after which the solution (chloride of tin) may be transferred to another vessel and diluted with water. Pour into the chloride solution a strong solution of caustic potash, which will form a precipitate which will become dissolved by adding more of the potash solution. From 2 to 3 ounces of metallic tin to each gallon of bath will make a good solution. This must be worked with an anode of pure tin; but since this is but sparingly soluble in caustic potash, it will be advisable to adopt the method suggested at page 241 to keep up the strength of the solution. The activity of the bath may be increased by adding a moderate proportion of cyanide and a small quantity of liquid ammonia.

Some of the salts of tin are soluble in liquid ammonia, caustic potassa, or caustic soda, and the metal may be deposited from either of these solutions: a little cyanide favours the rapidity of the deposit. Tin may also be deposited from an acid solution, the protochloride for instance, and a very beautiful effect is produced by bringing the anode and cathode within an inch of each other, in which case a fine mass of *crystals of tin* will start out from the negative pole,

approach the positive pole, and gradually assume many beautiful and eccentric forms. The slightest motion causes the crystals to fall from the electrode.

Zinc.—Many persons have tried to deposit this metal from acid solutions—more especially from a solution of the sulphate—but for all practical purposes the processes have been a failure. The principle of depositing metals upon each other from acid solutions is bad, owing to the fact that the metal, when coming in contact with the acid solution, generally becomes acted upon without the aid of the battery.

In 1855 I patented a process for depositing zinc from an alkaline solution, which gave exceedingly beautiful results, and the metal deposited thereby was tough, reguline, and otherwise well suited to many practical purposes. As I believe the process is susceptible of many practical applications, it will be found fully described in the subjoined

SPECIFICATION.

My Invention consists, firstly, in forming a solution for the purpose of coating iron or steel with zinc by galvanic agency. To form the solution I proceed as follows:—I dissolve 200 ounces of commercial cyanide of potassium in twenty gallons of water (rain-water or distilled water being preferable) in a suitable vessel; I then pour into this solution 80 ounces by measure of strong liquid ammonia (of the specific gravity of ·880 I prefer). Having stirred these compounds together, I place several large porous cells, such as those used in Daniell's batteries, in this solution, and pour into each of the porous cells as much of a strong solution of a cyanide of potassium (say, about 16 ounces

to the gallon) as will be equal to the height of the solution in the larger vessel; I then attach several pieces of metal, copper or iron by preference, to pieces of copper wire, which are then to be attached to the negative pole of a galvanic battery. These pieces of copper or iron are to be placed in the porous cells. I next attach a piece or several pieces of zinc to the positive pole of the battery, and I then immerse these pieces of zinc in the solution of cyanide of potassium and ammonia. For the above purpose I prefer using good milled zinc, the weight of which is to be ascertained before immersion; and I think it better to "pickle" the zinc slightly, previous to immersion in the cyanide solution, with dilute hydrochloric acid, after which process it should be well rinsed in clean water. The galvanic battery is now to be set in action, and allowed to continue in action on the above materials until the solution of cyanide of potassium and ammonia has taken up about sixty ounces of zinc, that is to say, about three ounces to the gallon of solution.

As soon as the pieces of zinc have been weighed to determine the amount dissolved into the cyanide solution, I dip them into dilute hydrochloric acid, and then rinse them, when they are placed aside for future operations, if necessary; the porous cells are then to be removed. I now dissolve 80 ounces of a carbonated alkali (I prefer the carbonate of potassa) in a portion of the above solution, and when dissolved I add it to the original solution, and stir the whole together for a few moments, after which I allow the solution to stand undisturbed until the sediment formed has subsided; I then transfer the clear solution to another vesse., when it is ready for use.

The above solution may be made in a more concentrated form, say, with half the quantity of water, and it may be diluted down to the required strength by adding more water when wanted to be worked. I prepare cast or wrought iron or steel to be coated with the above solution in the following manner, having first made a pickle composed of,—

Sulphuric acid	1 pound.
Hydrochloric acid	½ ,,
Water	2 gallons.

The articles to be coated are first plunged into the above pickle, and allowed to remain until the oxide of iron is easily removable with a brush, sand, and water. As soon as the articles are sufficiently pickled, they are to be rinsed in clean water, and are then to be cleaned with a hard brush, sand, and water; and any oxide which may not have been quite removed by the pickle may be scraped or otherwise removed, or the article be returned to the pickling bath until these parts yield to the brush and sand; or the iron or steel may be cleaned by the processes ordinarily used at the "galvanised iron works." When the articles to be coated are quite free from oxide, they are to be well rinsed in clean water, and immediately placed in the zincing bath, in connection with the negative pole of the battery.

As soon as the articles have received a slight coating they should be removed from the bath and examined, in order to ascertain if there are any parts remaining unclean, in which case those parts should be cleaned, and the whole article once more brushed all over as before and then returned to the bath, where it is to remain until sufficiently coated. It is as well, however, to move the article about in the solution occasionally

in order to insure an uniform deposit. As soon as the articles are sufficiently coated they are to be removed from the bath and rinsed in clean water (hot water being preferable), and they may then be placed in saw-dust to dry them. The articles may be rendered bright either by means of the scratch-brush, or by gently scouring with silver sand, water, and a soft brush. When the above solution has been in use some time it will be necessary to add occasionally a little cyanide of potassium and liquid ammonia, so as to keep the solution at as near as possible the original strength; and if the solution, from being worked with too small a surface of positive electrode, or from other causes has become deprived of a portion of its zinc, I place in the solution (by suspension or otherwise) several porous cells, which I fill with strong solution of cyanide of potassium, and into which I put pieces of copper or iron as before, in connection with the negative pole of the battery, and the zinc electrodes I attach to the positive pole of the battery, by which means I am enabled to keep up the strength of the solution. The above solution is to be worked with zinc electrodes (milled zinc being preferable), and it will be necessary in coating flat surfaces especially to place a piece of zinc on each side of the article to be coated; for instance, if sheets of iron are to be coated, they are to be placed in the solution alternately, that is to say, sheet zinc, sheet iron, sheet zinc, and so on, (the sheets of iron and zinc exposing about the same area of surface,) otherwise the surface opposite the zinc electrode will receive the greatest amount of deposit. I prefer using a battery which *yields a considerable* quantity of electricity, and the *action of which* can be maintained for a considerable

time without losing its power, by which means I not only secure a good deposit, but uniform results. The battery which I prefer is that known as Bunsen's battery, or a battery composed of carbon and zinc elements. Two or more 4-gallon cells of this battery may be used when large articles are to be coated, or when a considerable quantity of work is to be done in the bath at one time. When cast or wrought iron or steel has become much rusted, it may be cleaned with strong hydrochloric acid, or with a strong pickle composed of hydrochloric acid and water, but it must not be allowed to remain too long in this pickle, or the iron or steel will be acted upon.

Articles of cutlery may be coated by the above process to preserve them from oxidation or rust in damp climates or during sea voyages, &c., and as they will only need a slight coating for this purpose, they will not require to remain long in the bath. In pickling bright steel articles, I should not recommend the use of any hydrochloric acid.

Electro-deposition of Alloys of Metals.—Besides the metals already referred to, I have succeeded in depositing an alloy of copper and nickel, forming a very good quality of German silver, by dissolving German silver in nitric acid, precipitating with an alkali, and re-dissolving with cyanide of potassium.

Silver and gold—forming what jewellers term "green gold"—may also be deposited by adding to a solution of gold a small quantity of solution of silver, but the solution must be worked hot, and with weak battery power. Copper and gold may also be deposited together in the same way. However, the only alloy which seems to have *much* practical value in it is that of brass, and

an extensive manufacture is now being carried on in this art both in England and on the continent.

I trust that the reader will find in the foregoing pages sufficient practical matter to enable him to work the various processes described with facility and certainty of success. I have endeavoured to divest the details of any unnecessary technicality, and to give each process with as much conciseness and simplicity as possible, in order that the student might at once arrive at the readiest mode of setting to work. Those processes which I have dwelt fully upon, are those which I have found most practicable and economical, and consequently more likely to succeed in the hands of the uninitiated.

ELECTRO-METALLURGY.

PART II.

PRACTICAL NOTES.

1. Electro-platers will doubtless have noticed, when a very thin coating of gold has been deposited upon a silver article (a chain, for instance), and the article, after being accidentally broken has been repaired by hard-soldering, that the film of gold has almost entirely vanished from each side of the soldered spot—probably to the extent of an inch or two—by the heat of the blowpipe flame. The gold has sunk, as it were, into the silver, possibly alloying itself with that metal. We say *possibly*, because it is the opinion of some observers that such is really the case: we are inclined to think, however, that the disappearance of the gold film is due to the expansion of the silver by heat, which disturbs its molecular structure, and causes the infinitely minute particles (query, crystals) of gold to become at first separated, and subsequently absorbed, by contraction of the silver upon cooling. We are led to this view because we doubt whether the heat which reaches the farthest point from which the gold disappears would be sufficient to form an alloy in the proper sense of the term, although it would doubtless be so within the immediate range of the blowpipe flame. Whether this or the alloy theory be the most correct, we leave for further investigation. The fact, however, of the absorption—so to speak—of electro-deposited metals by the surface of

other metals when subjected to heat, has been taken advantage of, in the process termed "pyro-plating."

The rationale of the *pyro-silvering* process, which is specially applicable to steel and iron, is briefly this:—The article is first steeped in a boiling solution of caustic potash; it is then brushed over with emery, and afterwards with a steel brush and a solution of common soda, in which it is allowed to remain a short time. The article is next connected to the negative electrode of a strong battery and suspended in a hot solution of caustic soda, when hydrogen is given off freely from its surface, and after awhile it assumes a bright silvery lustre. After rinsing, the article is placed in a silver bath, with a metal plate (previously weighed) by its side, and this should be about equal to its own surface. This plate is weighed from time to time to indicate the amount of deposit received by the article itself, which is then rinsed and heated in a furnace until the silver has partially sunk into its surface. *Pyro-gilding* is effected by first depositing a layer of gold, then heating the article until this nearly disappears, after which a second and third coating are given and treated in the same way—the last layer remaining upon the surface.

2. If the operator requires to dissolve gold of inferior quality, for the purpose of making his gold solution, he should first treat the gold in the following manner:—To one ounce of alloyed gold of the same quality as that which "colored" gold chains are made of, add two ounces of silver. These are now to be placed in a crucible and melted in a furnace, a little borax being added as a flux. As soon as the alloy is *thoroughly* melted, it should be poured into a deep

vessel of cold water (kept well stirred in a circular direction all the time), and thus it will become "granulated," as it is termed. The granulated metal is now to be removed, and placed in a Florence flask, and to be treated with one part nitric acid and two parts water. This is allowed to digest for an hour or so; applying gentle heat when the chemical action diminishes in vigour. The nitric acid will remove all the copper and silver from the gold, which latter will remain at the bottom of the flask in the form of a dark brown irregular mass. The acid, which will have acquired a green colour, may now be poured into a separate vessel. It will be well to add a little fresh acid to the gold, applying heat as before, in order to be sure that all the copper and silver have been removed. If the acid does not produce chemical action (which may be seen by the absence of red fumes in the body of the flask), the operation is complete. The gold is now to be washed well with hot water, and the washings are to be added to the first solution which was poured from the flask. The gold in its present state may be dissolved with nitro-hydrochloric acid, and thus converted into chloride; or it may be dried, mixed with a little dry potash, and fused in a crucible. When melted, the gold may be granulated, or poured into an ingot.

The solution of nitrate of silver and nitrate of copper formed above, may be thus treated, in order to collect the former:—Put into the vessel containing the green solution a piece of stout sheet copper. In a few moments the silver will begin to deposit itself upon the copper, and by continuing the process for some time—adding a gentle heat, the whole of the silver will eventually

become precipitated in the form of minute crystals. In order to ascertain whether all the silver is thrown down, pour a little of the green liquor into a wine glass, and drop in a little hydrochloric acid, which, if any silver be still present in the solution, will form a white precipitate. If, on the contrary, no precipitation takes place, the green solution may be poured off and thrown away. The silver is to be washed several times, to free it from the copper, and when the last washings pass off clear, the silver may be dried and melted, with a little potash, in a crucible; or it may be dissolved in nitric acid and used for making a plating solution.

The copper may be thrown down from the above solution, when the silver is extracted, by immersing in the solution a few pieces of iron, but it is never worth while to do this except for experimental purposes. The solution, however, may be used with the sulphate of copper batteries.

3. Sometimes, when gilding the insides of mugs, tankards, &c., which are richly chased or embossed, it will be found that the hollow parts do not receive the deposit at all, or very partially. When this is the case, the article must be rinsed and well scratch-brushed, and a little more cyanide added to the solution. The anode should be slightly kept in motion and the battery power increased until the hollow surfaces are coated. Frequent scratch-brushing aids the deposit to a great extent, by imparting a slight film of brass to the surface.

4. Silver filagree brooches and articles which have been annealed and cannot be scratched bright, owing to their peculiarity of construction, are frequently troublesome to gild, for the rough surfaces caused by the fire, *in the process of* annealing, are indifferent conductors

of the current. It will therefore be advisable to scratch-brush the articles as far as practicable, and to add a little more cyanide of potassium to the solution in which this class of work is to be gilt. The article must be constantly moved about, in solution, until coated all over. The battery-power should be brisk.

5. When articles gild a "foxy" colour, as it is termed, this is either owing to the presence of too much cyanide, excess of battery power, or exposure of too large a surface of anode. When this defect shows itself, raise the anode a little and keep the article in motion while in the bath, or remove the anode altogether and move the work about in the solution for a few seconds. This will generally remedy the defect. The power of the current, however, should be diminished, or the anode will become wasted.

6. When a gold solution has been worked for a long time, it becomes contaminated with organic matter, and the deposit is of an inferior colour in consequence. In this case, I have observed that the solution may be restored to good working condition by evaporating it to dryness, and then adding distilled water to re-dissolve it. A little cyanide should then be added, and the solution filtered for use. The heat required to evaporate a solution to dryness does not, as many people suppose, impair the solution, or decompose it; it merely appears to destroy the organic matter and to prevent its influence in the working of the solution.

7. It is sometimes found impossible to make a gold solution work well which has been in use for some years, even evaporation to dryness failing to restore it. It is therefore better and more economical to abandon it altogether and make another. The gold from old solu-

tions may be recovered by means of the battery, or by precipitating the gold with acid. If the former plan is adopted, a piece of copper should be attached to the negative pole of the battery, and another piece (as an anode) be attached to the positive pole. When the battery has been in action for some time, the gold—or at all events the greater part of it—will be deposited upon the negative pole, from which it may be removed by mechanical means, or by dissolving it off with nitro-hydrochloric acid. If it is preferred to throw down the gold from the solution with acid, the solution must be placed in a large vessel *in the open air*, as the fumes which will arise are highly deleterious if breathed, and sulphuric acid poured in carefully until no further effervescence takes place. The precipitate formed should be allowed to subside, when the clear liquor may be poured off and thrown away. The precipitate may be washed with hot water; after which it may be dried, mixed with a little potash, and fused in a crucible until the gold is gathered into a button. The operator will seldom find that he can recover nearly the amount of gold that he put into the solution; owing to the irregularities of working, the solution becomes deprived of a considerable proportion of gold, and I have frequently found that old solutions will yield scarcely any metal worth speaking of.

8. In gilding, if a copper and a silver article be immersed in the solution together, the copper article will receive the deposit first, and the silver article will be troublesome to gild sometimes under such circumstances; and in trying to force the gold upon the silver, probably the copper article will receive the deposit so *quickly that it will* be liable to strip off when scratch-

brushed. The silver article, therefore, should be placed in the solution first, and when it is coated, the copper one may be suspended by its side.

9. Each metal to be gilt plated or brassed, should have a solution for itself, otherwise the bath in which several different metals have been coated, will become impaired, unless, however, each metal has first been coated by itself to some extent.

10. When it is found that the operator cannot, from some cause or other, produce a good colour when gilding, it is useful to have at command the means of improving the colour without the trouble and annoyance of persevering with an indifferent gold solution. Some gilders employ the following mixture to give an artificial colour to gilt work; and provided the work is strongly coated, it may be used with advantage:—

Alum	3 ounces.
Nitrate of potassa (saltpetre)	6 ,,
Sulphate of zinc	3 ,,
Common salt	3 ,,

Mix the above materials into the form of a thick paste, dip the articles in it, or brush them over with the compound, and place them on a piece of sheet iron. The iron is to be heated over a clear charcoal or coke fire, until the articles appear nearly black, when they are to be plunged into cold water. A very useful formula, and one which may be used with less care than the above—especially for small work, is the following:—

	OZS.	DWTS.	GRS.
Sulphate of copper	0	2	0
French verdigris	0	4	12
Chloride of ammonium (Sal ammoniac)	0	4	0
Nitrate of potassa	0	4	0
Acetic acid (about)	1	0	0

Reduce the sulphate of copper, sal-ammoniac and nitrate of potassa to a powder, in a mortar; then add the verdigris, and pour in, little by little, the acetic acid, stirring well all the time; the whole will assume a bluish-green mass. The article to be coloured is to be dipped into this mixture, and, being placed on a piece of sheet copper, heat is to be applied until it assumes a black colour. It is allowed to cool, and is then placed in a tolerably strong sulphuric acid pickle, which will dissolve the colouring salts, and the article will assume a rich fine gold colour. It is sometimes advantageous to scratch-brush the article before submitting it to the above process, and it will then come out of the pickle perfectly bright. The article, when removed from the pickle, is to be well rinsed in warm water to which a little potash has been added. A soft brush and soap and warm water, skilfully applied, will tend much to improve the article—especially if the work is either chased or embossed.

11. Moving the articles about in the bath, will at all times enable the operator to vary the colour of the deposit from pale straw-colour to a very dark red. The temperature of the solution likewise influences the colour of the deposit, the colour being lightest when the solution is cold, and gradually becoming darker as the temperature increases. Variations in the surface of anode exposed while the articles are in solution, will also alter the colour of the deposit. The amount of cyanide in the bath and the strength of battery-power, influence the deposit in the same way.

12. If there be not sufficient cyanide in the gold *solution,* the anode will not become freely dissolved; *consequently,* as has been shown, the solution will soon

become exhausted of its gold, and the articles gild of an inferior colour. Adding more cyanide, under such circumstances, will not remedy the defect, but a little concentrated solution of gold should also be added at the same time.

13. In gilding watch-movements, the greatest care must be observed with regard to cleanliness. The work is first to be placed in a weak solution of caustic potassa for a few minutes, and then rinsed in cold water. The movements are now to be dipped in pickling acid (nitrous acid) for *an instant*, and then plunged *immediately* into cold water. After being finally rinsed in hot water, they may be placed in the gilding-bath and allowed to remain until they have received the required coating. A few seconds will generally be sufficient, as this class of work does not require to be very strongly gilt. When gilt, the movements are to be rinsed in warm water, and scratch-brushed; they may then be returned to the bath, for an instant, to give them a good colour. Lastly, rinse in hot water, and place the movements in clean box sawdust. An economical mode of gilding watch-movements, is to employ a copper anode—working from the solution—which must be re-supplied with gold from time to time as the solution becomes exhausted.

14. When an article is immersed in the silver solution, if it assumes a dark colour, either the solution is too rich in cyanide, the battery-power is excessive, or too large a surface of anode is employed. Any one, or all of these conditions combined, will cause this defect. The operator should at once remove the article (unless it be made of Britannia-metal, pewter, or lead), and have it cleaned again by the usual process. It may

then be returned to the bath, and a much smaller surface of anode exposed. This will at once alter the colour of the deposit, and the anode can be lowered a little from time to time, to increase the speed of the operation. Should the article, however, still receive a dark-coloured deposit, either the solution must be weakened with water, or the battery-power reduced. But the solution should not be altered until the other remedies have been tried.

15. When it is desired to give to a plated article, or a portion of the same, that appearance which is technically termed "oxidation," any of the following processes may be employed with success. Sometimes very pleasing effects may be produced upon silver work by the "oxidising" proceses.

1. Dissolve 1 dwt. of platinum in *aqua regia.* Evaporate the acid, and when the resulting red mass is quite cold, dissolve in a little sulphuric ether or alcohol. Or the chloride of platinum may be dissolved in cold water, or used, in its acid state, before evaporation. Apply with a camel's hair pencil to those parts which are required to be "oxidised," and as soon as the spirit or ether has evaporated, the pellicle of platinum remaining will give the appearance required.

2. Sulphate of copper . . . . . 2 dwts.
Nitrate of potassa . . . . . 1 „
Muriate of ammonia . . . . . 2 „

Dissolve in a little acetic acid. Apply with a camel's hair pencil. The article should be warmed before using this mixture.

3. Hydrosulphate of ammonia, strong or diluted, will *give either a* dark or light tint of oxidation.

4. The fumes of sulphur will give to silver an extremely beautiful blue steel-like surface. The operation should be conducted in a closed box, all parts of the article not to be coloured being protected with a suitable cement or wax.

5. Nitric acid alone will produce an oxidised surface upon silver.

16. Certain parts of an ornamental silver article may have a very pleasing effect produced upon them by oxidising some parts, gilding others, and then depositing a slight coating of copper upon small portions of the article, which may be done in the following manner:—Dissolve a little sulphate of copper, and add a few drops of sulphuric acid; apply this solution to the part to be coated, with a camel hair brush, now touch the moistened part with a piece of steel wire, and it will instantly become coated with copper. Any design can be worked in copper by this means; but it is not necessary to state, that the amount of copper deposited is very trifling, consequently the article should not be subjected to much wear.

17. When a silver solution works badly, and it appears impossible to restore it by the ordinary means, the operator may precipitate the silver with sulphuric acid in the manner described for gold (page 130). The precipitate is to be well washed, and may then be re-dissolved with cyanide of potassium. Water is then to be added to make the required amount of solution, and in all probability it will work as well as ever. The solution should be filtered before using, which may be conveniently done before adding the bulk of water.

18. If, when silver anodes are used, the solution contains a great excess of free cyanide, the anodes will

dissolve away irregularly, and sometimes numerous small particles of silver drop off the anode; these particles, if allowed to fall on the work to be plated, will render it rough. It is therefore, under such circumstances, advisable to place the anode in a canvas bag, or a bag made of Holland linen, by which means the small granules of silver will be retained, and may be collected from time to time, and melted or dissolved to make nitrate of silver.

19. In "stripping" articles, by the process given at page 56, the operator must take care that the fumes arising from the process are not allowed to enter the apartment in which he is operating, as they are exceedingly offensive and injurious. The process may be carried on upon a sand-bath, with a flue above, or upon the hob of an ordinary stove.

20. Sometimes the silver thrown down from stripping solutions, when melted and cast into an ingot, will not, if submitted to the "flatting-mill" to be rolled out, roll well, but will crack under the operation. This defect is probably owing to the presence of a small quantity of zinc. It is better, in such a case, to remelt the silver with a small portion of copper, or to throw in some nitrate of potassa when the silver is in a state of fusion.

21. When silver or electro-plated articles have become much tarnished by exposure to the atmosphere, the surfaces may be cleaned by brushing over them a strong solution of cyanide of potassium; or strong liquid ammonia will answer the same purpose. Jewellers' rouge, in the form of a paste, applied with a stiff brush, will render the surface of chased work clean, *but the bright* surfaces should be polished with the

palm of the hand, and moist rouge, which is rubbed on until it becomes quite dry, and the hand appears black from the silver which has worked off the article by friction. When the articles are very dull, a little rotten-stone may be applied before the rouging process.

22. Gold may be stripped from articles which have been gilt, by placing them in strong nitric acid, to which a little dry common salt has been added. When the gold is removed, the articles should be at once rinsed and cleaned in the ordinary way. When the nitric acid stripping solution has been worked a good deal it removes the gold but tardily; it should then be cast aside, and the gold collected by evaporating the solution to dryness, and fusing the residuum with a little potassa or soda. When the gold is fused into a button, a little nitre may be added occasionally, in order to refine it thoroughly.

23. As deposition takes place more rapidly upon those surfaces which are nearest the anode, it will be necessary, in order to coat the goods as uniformly as possible, to move them occasionally, and to present a different surface to the anode. By doing this frequently, a tolerably uniform deposit may be secured. Or the anode may be shifted to effect the same result. Presuming that electro-deposition takes place principally where the article is in "electrical sight" with the anode, it is well to surround the work with surfaces of metal to be dissolved, which will save the necessity of frequently moving the articles in solution.

The insides of cream-ewers, sugar-bowls, teapots, &c., since they cannot be placed in such a position that the insides will be exactly opposite the anode, may first receive a *deposit* inside by filling the vessel with silver

solution, and proceeding in the same way as in gilding the inside of a vessel. Or this may be left until the article is well coated outside. Generally speaking, it is better to let the solution be slightly moved occasionally, in order to expose fresh surfaces of the solution to the work being plated.

24. Stout copper wires conduct the current better than fine wires; consequently, the wire employed in connecting the work to be plated and the anodes with the battery should be always sufficiently stout to carry the current freely. For a single cell, wire about one-sixteenth of an inch in thickness will be sufficient, but where a series of cells are employed, in electro-brassing for instance, the wire should be much thicker,—say at least one-eighth of an inch thick. If too thin a wire is used, when the battery is in circuit,—that is, when it is connected with the anode and goods to be coated,—the wire will sometimes become quite hot, owing to its being unable to convey the amount of current generated.

25. It is always advisable to commence the process of electro-deposition with moderate battery power, which may be augmented after a little while, except in those cases referred to in a former part of this work. If too strong a current is employed, the articles will, in all probability, "strip" in the process of scratch-brushing or burnishing. Again, when the battery power is very strong, the solution becomes decomposed. As a rule, no effervescence or frothing should be allowed to take place in a plating bath.

26. Electro-deposition will proceed much quicker when the temperature of the atmosphere or solution is *high; therefore*, the operator should observe that the

surface of anode be not too great at first, or the battery power excessive, or the deposit will be faulty. Whenever a warm solution is employed, deposition should be allowed to commence slowly at first, gradually lowering the anode as the coat thickens.

27. Deposition from silver or gold solutions takes place more actively upon brass, German silver, or copper, than upon silver or gold; therefore the operation must be carried on slowly at first. When a copper or brass article becomes covered with silver, deposition does not proceed quite so rapidly as at first, when the inferior metal was exposed in the solution; the manipulator may therefore accelerate the speed of the operation as before recommended. The same operation applies to gilding. Gold is more easily deposited upon brass or copper than upon gold; therefore, after the first layer has been deposited, the operation may be carried on more vigorously.

28. The apartment in which electro-deposition is carried on should be kept as dry as possible, and the temperature at about 60° F. In warm weather, when the apartment assumes a higher temperature, the strength of battery power, &c., should be regulated accordingly, otherwise deposition will take place too rapidly.

29. Batteries employed for this purpose, should be made to work as uniformly as possible. When a battery works slowly, it is better to take on an extra cell of about equal power, than to make frequent additions of acid to the battery, which is apt to cause it to act irregularly.

30. The zinc employed in a battery, when not excited by salt and water, should be "amalgamated." This

is accomplished by placing some mercury in a dish with a little hydrochloric acid. A piece of flannel or baize, tied to the end of a stick, and dipped into the acid and mercury, is to be rubbed all over the cylinder or plate of zinc, until it assumes the characteristic brightness of mercury. When a cylinder of zinc is to be amalgamated, I have found that putting mercury into a coarse flannel bag, dipped now and then into hydrochloric acid, and applying it first to the outside of the cylinder, renders the process of amalgamating this surface very simple and effective, when only a small quantity of mercury is at hand. This is a very economical method, as with care little or no waste of mercury occurs. When the amalgamated plate or cylinder has been in work some time, the operator should observe if "local action" is taking place upon any part of the metal. When this is the case, it is accompanied by a violent effervescence within the cell. The cylinder should be at once removed from the cell, and those parts which have been most violently attacked by the acid solution, must be re-amalgamated. Where local action takes place, the part is generally of a dull and dark grey colour.

31. The copper cylinders and plates used in batteries, should be occasionally cleaned with dipping nitrous acid, and then rinsed in cold water, or they may be scoured with sand and a hard brush.

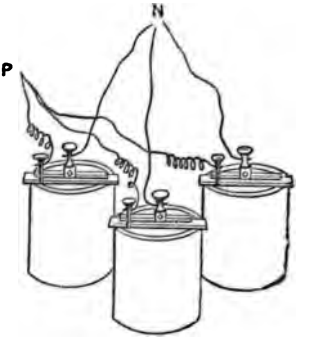
32. When the copper conducting wires become corroded by being splashed with solution, &c., they should be cleaned with a piece of emery cloth. I have found it advantageous to coat these wires with silver—this metal being less liable to corrosion than copper.

33. In using binding screws for connecting the wires

of a battery with the anode and goods to be coated, the operator must take care that the connection between the point of the binding screw and the wire is clean, otherwise the current will be conveyed partially or not at all. It is well to slightly file the point of the screw before using it, or to roughen it with a piece of coarse emery cloth, which will enable it to *grip* the wire better. The hole through which the wire is passed, may be kept clean with a small round file. When binding screws become very much corroded, they may be pickled in sulphuric acid and water, for a few hours, and then cleaned with a hard brush and sand; or they may be dipped in nitrous acid.

34. Strips of sheet copper will be found very convenient substitutes for copper conducting wires. The strips may be cut from a sheet about $\frac{1}{32}$ of an inch in thickness.

35. In working a battery for electro-deposition, the operator must secure a considerable *quantity* of electricity of sufficient *intensity* to give the necessary activity to that quantity. I prefer, when arranging two or more cells of a battery, to deposit silver, attaching the wires connected with the zinc elements to the metal rod on which the articles to be coated are suspended, and the wires proceeding from the copper elements I attach to the anodes. By this arrangement, the quantity is multiplied by the number of cells employed; whereas,



if the cells are alternated—that is, the zinc of the one cell to the copper of the next, and so on—the intensity is multiplied and the arrangement only gives the quantity of one cell.

36. When it is desirable to deposit the metal in a *hard* state, it may be advantageous to alternate the cells, so as to increase the *intensity* of the current, as this quality of current seems to affect the nature of the deposit. A good tough reguline deposit appears to be dependent upon the current being feeble in intensity, but considerable in quantity.

37. In depositing brass, however, the reverse seems to be the case, for here greater intensity is absolutely necessary, or the copper alone will be deposited. I have generally found that at least two cells of the zinc and carbon (an intense) battery, alternately arranged, have been necessary to obtain a deposit of good colour. Again, if the battery be too powerful, the zinc only will be deposited. The exact *mean* appears to be absolutely necessary to obtain good results in electro-brassing.

38. When the anodes are only partially immersed in the solution, and have been worked for some time, the metal will dissolve off rapidly at the surface which is just out of the solution, and probably the anode may be divided, and fall into the solution. It is advisable, therefore, occasionally to shift the position of the anode in order to prevent this local action upon it. It is a good plan to suspend the anodes employed in gilding by stout platinum wires, so that the whole of the anode may be immersed when necessary, without the solution being injured.

39. In preparing solutions, more especially gold and *silver solutions*, distilled water should be employed;

but, when large quantities of solution are required, this may be inconvenient; therefore, rain-water, if it can be obtained, may be substituted; or water which has been boiled, losing some of its impurities, may be used in preference to common water. Pump-water is very objectionable. If rain-water is employed, it should be filtered before using; and it is better to collect it as it falls *direct* from the atmosphere, rather than use that which falls off the roof of a house, &c.

40. Electro-deposition of gold and silver may be carried on by the "single cell" arrangement; but, although very good results may be obtained by it, it is of very little commercial importance. The operations of gilding and plating, when conducted by the separate battery, are so simple that even the "single cell" process, simple as it is, will scarcely be employed, except for experiment.

41. In gilding or plating by the "single cell" process, however, a jar is fitted with a cylinder of zinc inside, which is excited either with sulphuric acid and water, or salt and water. A porous cell is placed in the centre, which is filled with either gold or silver solution. A strong copper wire is soldered to the zinc, to which the article to be gilt or plated is suspended, by means of a thinner wire, and the moment the article is immersed deposition takes place.

42. It is advisable to *anneal* the anodes before using them. This may readily be done by making them red hot over a clear fire (a charcoal fire being preferable), and then allowing them to cool. The anodes of gold, silver, copper, and brass may be plunged into dilute sulphuric acid after they have been annealed, by which their surfaces will be rendered quite clean and free from

the "fire mark." Brass and copper anodes may be dipped in nitrous acid for a moment, and then plunged into cold water.

43. Cyanide of potassium may be prepared, for electro-chemical purposes, by the following process:— A quantity of commercial ferrocyanide of potassium is to be reduced to a powder; it is then to be roasted on an iron slab, or piece of sheet-iron with its edges turned up to prevent the material falling off. The heat is to be continued until the substance is quite free from water of crystallisation, which will become evident by its losing its transparency. If the heat be applied too suddenly, the ferrocyanide is apt to *decrepitate*, and much of it may be lost. Care must also be taken not to apply too much heat, or it will become fused to the iron slab. When the ferrocyanide is dried, it is to be mixed intimately with *dry* carbonate of potassa, in the following proportions:—

Dried ferrocyanide	16 ounces.
,, carbonate of potassa	8 ,,

Both materials being well mixed, they are to be placed in an iron crucible or ladle, which should be previously made hot, and the whole subjected to a strong heat in a coke fire; the heat may be increased as fusion progresses. When the substances have fused into a liquid, they are to remain in this state for about a quarter of an hour; the crucible is then to be removed from the furnace, and its contents allowed to settle for a few moments; the clear liquid may then be carefully poured out, either into a shallow iron mould or upon an iron slab or dry flag-stone. The sediment remaining *at the bottom* of the crucible should be shaken

out while hot, or it will be troublesome to remove it. It is a good plan, while the cyanide is fusing, to dip an iron rod into the mass occasionally, and then to examine the portion thus removed, which will be brown at first, and subsequently white when the process has been carried far enough.

44. Sometimes electro platers have employed ferrocyanide of potassium (yellow prussiate of potassa) instead of the cyanide in forming silver solutions, but this substance has not been found to answer well, since it has not the power of dissolving the anode, therefore the solution soon becomes exhausted of its silver. Again, it requires so large a quantity of the ferrocyanide to keep the solution in action, that eventually it crystallises upon the inner surface of the bath.

45. Hyposulphite of soda has also been employed as a substitute for the cyanide of potassium; but since the solution which is formed with it is very readily acted upon by light, it is never likely to become much employed; besides, the solutions made with cyanide of potassium are found, for all practicable purposes, infinitely superior to those made with this or any other substitute.

46. It is generally necessary to employ two or more Bunsen's cells for depositing brass; though small articles may sometimes be coated by means of a single cell. The colour and brightness of the deposit, however, are so much influenced by the energy of the current, that it is never advisable to employ a weak battery when depositing this alloy. Under favourable conditions—that is to say, the brassing solution having been carefully made, the battery power suitable, and the proper surface of anode immersed in the bath, it is

quite possible to deposit an alloy of zinc and copper of so rich a colour as to be scarcely distinguishable from fine gold when placed beside that metal. On the other hand, when the solution is defective, the current weak, or of feeble tension, the deposit will be of a dull, pale, yellow colour. Again, when the solution has been in use some time (more especially if it has been worked hot), as the ammonia evaporates a white salt of zinc forms upon the surface of the anode, which not only retards the action of that electrode, but also affects the equilibrium of the solution, by reason of this part of alloy not entering into the solution. To keep up the proper equivalent proportion of the two metals liquid ammonia must be added occasionally, and if the anodes exhibit a dirty appearance, additional cyanide will also have to be used. Before applying fresh cyanide, the battery should be examined, all connections well looked after, and if necessary, the acids renewed.

Some electro-depositors prefer working the brassing bath at a temperature of about 130° Fahr., or even higher ; and, indeed, where it is convenient to apply heat to the solution it is better to do so, inasmuch as the operation is not only hastened, but a more uniform deposit is likely to be obtained than with a cold bath, provided the electric current is properly regulated. In working a hot solution, however, a much smaller surface of anode must be exposed, and weaker electric power employed. It will also be necessary, unless the resistance coil (page 116) is used, to regulate the surface of anode to that of the articles in the bath. It is obvious also that by heating the solution, its ammonia will be expelled, therefore it will be necessary *to depend* upon additions of cyanide to keep the bath *in active condition.*

47. Silver articles which are required to be left a dead white should be thus treated :—The article is first to be heated to "cherry redness" (*i.e.*, a dull red heat), and is then to be allowed to cool. When quite cold it is to be placed in a pickle of *very* dilute sulphuric acid (about 5 parts acid in 100 parts water). The article should remain in this pickle for an hour or two; and if not sufficiently uniform in surface, it should be rinsed in hot water, dried spontaneously, and again heated as before—the operation of pickling being repeated. As the object in this process is to remove the copper with which the silver is alloyed, the repeated pickling will not produce any injurious result, but will merely remove the copper from the *surface* of the article, leaving fine silver alone upon the surface. A solution of alum in water may be substituted for dilute sulphuric acid, if preferred. In either case the solution should not be used more than once or twice, and then be thrown away.

After the article has been *whitened* as above, it must be removed from the pickle, and be well rinsed in hot water, which for this purpose must be absolutely clean, and then placed in warm box-sawdust. It is well to keep perfectly clean box-dust for articles which have to be whitened, as the slightest stain in some cases would be fatal to the object sought. In whitening silver watch-dials, great care must be taken not to warp the dial in the process of annealing. The dial should be placed on a perfectly flat piece of charcoal,* face upward, and a gentle blast with the blowpipe carefully applied, and as far as practicable the flame should play *all over* the surface of the dial without

* A flat surface may be given to charcoal by rubbing it upon a flag stone.

absolutely touching it, by which means the dial will soon become sufficiently heated, without becoming warped or in any way injured. Silver dials may also be annealed by placing them upon a flat sheet of copper, which is then brought in contact with a clear fire until red-hot.

48. Brass time-piece dials may be whitened, *i.e.*, silvered, by rubbing a mixture of chloride of silver (silver precipitated from the nitrate with common salt or hydrochloric acid) and common salt. The mixture should be worked up into a thinnish paste, and be applied with a soft cork or piece of washleather. The dial is then to be rinsed and placed in box-dust.

49. The sediment which accumulates in the scratch-brush box should be carefully preserved and dried, and this, with other waste of a similar description, collected and fused with dry carbonate of potash; and as the resulting "button" will be an alloy of gold, silver, copper, &c., it will be necessary, in order to refine it, to proceed as follows:—Remelt the alloy, and "granulate" as before described; then place the grains in dilute nitric acid (2 parts acid to 1 part water), which will dissolve all but the gold, the latter remaining as a brown powder at the bottom of the vessel in which the operation is conducted. The solution formed should next be poured off into a jar or basin, and a piece of copper immersed, which will at once throw down all the silver. The silver and gold thus obtained will require to be well washed with hot water, and finally dried and fused.

50. Gold articles may be "coloured," as it is termed, by immersing them in the mixture described at *page 131, line 17.* The mixture should be placed in

a common pipkin, and allowed to fuse, the articles being removed occasionally to ascertain if they be of good colour. After the articles have been removed from the pipkin, they should be allowed to cool, and then immersed in dilute sulphuric or acetic acid, which will remove the flux. When this is done, the articles may be rinsed in a weak solution of potash or soda, and finally brushed with hot soap-and-water; they must then be rinsed in hot water, and placed in clean warm box-saw-dust. A badger-hair brush is the best to remove all traces of sawdust from articles which have been dried in it.

51. In gilding cast brass articles, which are required to be left dead in the hollow and chased surfaces, the best plan is first to wash the article in a solution of caustic soda (a solution of soapmaker's "soda ash" will do) or potash, then, after well rinsing, dip the article *for an instant* in fuming nitric acid, and after it has become thoroughly acted upon all over plunge it *instantly* in cold water: the article should then be well rinsed in hot water, and is then ready for the gilding bath. Articles of this description seldom require to be strongly gilt, the *colour* being the principal object. The *bright* surfaces may require to be burnished.

52. Electro-gilders and platers will do well to keep several burnishing tools on hand for small things which may be needed in a hurry, or which would not be within the ordinary province of a professional burnisher to accomplish. As mere friction is required, the operator may easily acquire the proper knack of using the tools. A small steel burnisher, about twice the size of a ladies' "stiletto" or eyelet-hole piercer, is a convenient tool for edges of brooch mounts, &c.

53. *As it* may be necessary that the electro-plater

should be able to solder an article at a moment's notice rather than send it out to be done, he may derive advantage from the following hints:—The operator is to be provided with an ordinary "soldering iron" (which is made of copper, by the way!), and the face must be filed smooth with a keen file; after which it should be placed in a fire until hot, but not *red* hot. The soldering iron should then be "tinned," as it is termed; that is, rubbed on a piece of sheet tin with a little rosin and soft solder. As the face of the tool will have become slightly oxidised after removal from the fire, it will be necessary to pass the file over it again in order to clean the surface to be tinned. The moment this is done, plunge it *at once* into the rosin and solder, and by gently working the soldering iron over the surface of sheet tin, it will become coated with solder and fit for use. The soldering iron should never be allowed to be heated to redness, otherwise the solder becomes "burned," as it is termed, and, uniting with the copper, forms a hard alloy which the file will scarcely touch unless the tool is very hot. In soldering an article, the first thing to do is to clean the part to be soldered, which is generally done by scraping the surface with a sharp instrument, such as the point of a penknife, or, still better, a three-square scraper made out of an ordinary three-square file, and great care is necessary to ensure all parts which are to receive the solder being perfectly clean. The operator should provide himself with a solution of chloride of zinc, which is made by dissolving a few pieces of zinc (say half an ounce) in an ounce of hydrochloric acid; this solution may be kept in a wide-mouthed bottle ready for use. The solution of chloride of zinc is applied to the parts to be soldered with a

camel-hair brush or the feather of a quill. As soon as this is done, and the parts to be soldered are brought together, the soldering iron should be again heated until it is hot enough to melt the solder freely. It should not only do this, but also take up a *globule* of the melted solder and hold it in suspension until borne by the operator to the part to be soldered. The instant the soldering iron touches the surface to which the chloride of zinc has been applied, the solder will "run" and attach itself readily. It will be necessary to hold a strip of solder in the hand, in order to apply more as required. Rosin may sometimes be employed instead of the chloride of zinc, but as a rule the latter will be found preferable. In connecting copper wire with zinc plates, the solution of chloride of zinc may advantageously contain an excess of acid; in fact, hydrochloric acid alone may be employed in the same way as the chloride of zinc. Small articles may be united with soft solder by the aid of the blowpipe. In this case the solder should be hammered flat, and, after being scraped clean, cut into small pellets; that is, first cutting the solder into strips and then cross-cutting into small squares. These pellets are to be placed upon the article to be soldered (after the parts have been scraped as before, and the chloride of zinc applied), and a jet of flame gently blown upon the article with the blowpipe will readily unite the parts.

54. All goods which are to be plated or gilt should be placed in the bath as soon as possible after being cleaned or scratch-brushed and rinsed: if they are allowed to remain long in water, or exposed to the air, a film of oxide is formed upon the surface of the metals, and which, however slight, has a tendency to prevent

the gold or silver adhering firmly to the metal to be coated. It is not a good plan to prepare too many articles at one time for the bath, allowing them to remain in water until a quantity is ready: it is better to get them into the bath as quickly as possible, a few at a time, of course taking care that the surface of anode exposed and the battery power are regulated according to the *surface* of goods immersed in the bath at one time. When the number of things in a bath is increased, the anode must be lowered and the battery power rendered more vigorous. As we have said before, silver and gold do not receive the deposit of these metals so freely as copper, brass, German silver, &c.; therefore, when these metals have become coated to a certain extent with the superior metals, the battery power may be judiciously augmented and the surface of anode increased.

55. A very useful solution of silver or gold for plating or gilding without the aid of a battery may be made as follows:—

Take, say, 1 ounce of nitrate of silver dissolved in 1 quart of distilled or rain water. When thoroughly dissolved, throw in a few crystals of hyposulphite of soda, which will at first form a brown precipitate, but which eventually becomes redissolved if sufficient hyposulphite has been employed. A slight excess of this salt must, however, be added. The solution thus formed may be used for coating small articles of steel, brass, or German silver, by simply dipping a sponge in the solution and rubbing it over the surface of the article to be coated. I have succeeded in coating steel very satisfactorily by this means, and have found *the silver so firmly* attached to the steel (when the

solution has been carefully made) that it has been removed with considerable difficulty. A solution of gold may be made in the same way, and applied as described. A concentrated solution of either gold or silver thus made may be used for coating parts of articles which have stripped or blistered, by applying it with a camel-hair pencil to the part, and touching the spot at the same time with a thin clean strip of zinc.

56. To the practical electro-plater, and even the amateur, it may be useful to become acquainted with the art of "hard soldering," as it is termed; and as there is frequently, especially in small provincial towns, a difficulty in getting even a small job executed with dispatch, we will give the reader a few hints upon the manipulation of this process.

"Hard soldering" consists in uniting any two metals, or parts of the same metal, by means of an alloy composed of two parts of silver to one part of brass. The silver and brass should be melted together as follows:— Having obtained a broad piece of good charcoal, scoop out a slight hollow on the flattest surface to receive the alloy. Now place the metals in the hollow, and fuse them by means of a blowpipe, using either a jet of gas or an oil lamp with a good broad wick. As soon as the metals become hot, touch them with a crystal of borax (borate of soda), which will immediately fuse, and act as a flux. The jet of flame must now be vigorously employed until the metals are completely fused. The fusion may be continued for a few moments in order to ensure perfect amalgamation. When the "button" of solder is well melted, the flat surface of a hammer may be placed quickly upon it, by which means it will become flattened; in this form it may be readily beaten

out (unless a pair of steel rollers are at hand) until sufficiently thin to cut with a pair of jewellers' shears. The solder can be hammered or beaten out upon any solid iron surface; but, as each time the blow is given the alloy becomes harder, it will be necessary from time to time to *anneal* it, *i.e.*, place it again upon the charcoal, and apply the blowpipe flame until the alloy is of a "cherry-red" heat; it must then be plunged into cold water, and is ready for beating out or rolling, as the case may be. The object being to make the solder as thin as ordinary card, or even thinner, when the operator is without a pair of rollers he must use the next best substitutes—a hammer and patience. The solder, before being used, must be scraped with a keen steel edge, and then partly cut into thin strips, and these again cross-cut into small pieces or pellets about one-sixteenth of an inch square. These pellets may be cut when required for use, or kept in a clean box used for the purpose. The operator should next provide himself with a clean piece of slate, say about three inches square, and a small phial filled with water, and having a cork with a small groove cut in it from end to end. The bottle is used to apply moisture a drop at a time, whilst a large crystal of borax is rubbed upon the slate. By this means a thick creamy paste of borax is obtained upon the slate, which will be used as directed presently. The parts to be united or soldered must now be scraped clean *wherever the solder is expected to adhere,* and, with a camel-hair brush or quill feather dipped in the borax paste, brush over the parts to be soldered. A few pellets of the solder may be placed on the dry corner of the slate, and with the extreme point of the brush

moistened by the paste one pellet at a time may be readily taken up, and placed upon the prepared surface of the article. The article should be placed upon a flat piece of charcoal (made flat by rubbing on a flag-stone), and, if necessary, tied to it by thin "binding wire." A gentle blast of the blowpipe will at first dry the borax, and the flame must then be increased (holding the blowpipe some distance from the flame, in order to give a broad jet), and in a few moments, if the jet is favourable, the solder will "run," as it is termed, into every crevice, and the blowpipe must be *instantly* withdrawn. A very little practice will make the operator expert in this interesting art, and it will be advisable for him to practise upon articles of little value until he has not only acquired the use of the blowpipe, but also the proper kind of flame to make the solder run freely. After an article has been hard soldered, it is allowed to cool, or may be at once placed in a weak solution of sulphuric acid (a few drops of acid to an ounce of water), which, after a few moments, will dissolve the borax flux which remains after the soldering is complete. The article should now be rinsed in cold water and dried.

In carrying out the above operation, it would be well to be provided with everything necessary for the purpose (and, in fact, this should always be the first consideration of the student in practising a new art), as the absence of any requisite would not only entail disappointment, but failure.

57. When a zinc plate is imperfectly amalgamated, local action will set in, and the zinc element becomes powerfully acted upon by the acid employed in the

battery. When this is the case, there is evolution of gas from the battery cell. The zinc plate must be withdrawn and re-amalgamated, the part most acted upon being particularly attended to. When a single zinc plate and two copper plates are used, this local action will take place if the copper and zinc elements are too close to each other, in which case the zinc plate generally becomes most freely dissolved towards the centre, but at the upper part of the plate.

58. In order to prevent the zinc plate being *cut off* or dissolved at that part which is between the atmosphere and its contact with the acid solution, it is advisable occasionally to add a little more water to the battery, so as to bring the solution higher up the plate. It is also a good plan to raise the plates a few inches out of the bath occasionally, or to stir the acid solution gently with a stick.

59. When there is a want of activity in the battery (the acid solution being in good order), it may be as well to look to the connections. The binding-screws may require cleaning (a smooth file being used for the purpose, or a piece of emery-cloth wrapped round a flat piece of wood), and the ends of the wire should be well rubbed with emery-cloth.

60. When certain parts of an article require to be gilt whilst others are to be left silvered, it will be necessary to apply certain preparations to the parts to be protected. For this purpose many preparations are used. A solution of gum copal or mastic may be applied with a camel-hair brush; but, unless these varnishes are tolerably thick, they are apt to run. The composition described at page 59 may be used for this *purpose, but it will* not be safe to use it in hot solutions.

In some cases a strong solution of shellac in alcohol may be used to cover certain parts of an article which require protection.

61. In gilding chains, brooches, pins, rings, and other articles which have been repaired, *i.e.*, hard soldered, sometimes it is found that the gold will not deposit freely upon the soldered parts; when such is the case, a little extra scratch-brushing applied to the part will assist the operation greatly, and I have sometimes found that *dry* scratch-brushing for an instant—that is, without the stream of beer usually employed—renders the surface a better and more uniform conductor, and consequently it will more readily receive the deposit. In fact, dry scratch-brushing is very useful in many cases in which it is desirable to impart an artificial coating of brass upon an article to which silver or gold will not readily adhere. In scratch-brushing without the employment of beer, or some other liquid, however, great care must be taken not to continue the operation too long, as the minute particles of metal given off by the scratch-brush would be likely to prove prejudicial to the health of the operator were he to inhale them to any great extent.

62. In gilding or silvering steel articles by the processes described in paragraph 55, it will be necessary to clean them with a little diluted potash in order to remove grease; and if the articles are polished steel, the friction applied must be brisk, when first employing the solution, to ensure an even coating. Penknives, scissors, razors, and other similar goods may be lightly coated with either gold or silver by the solutions described, but it must be understood that the coating is more for beauty than for wear. If properly done, however, the

coating will last a considerable time without removal. Needles gilt and silvered in this way are very agreeable to work with, and form an elegant article for ladies' use.

63. As cyanide of potassium, which is so extensively employed in electro-metallurgy, is a highly poisonous substance, the apartments in which electro-gilding and plating are conducted should be well ventilated, and the solutions always be placed in such a position as to be nearest the window or chimney. Breathing an atmosphere impregnated with the vapour arising from the gilding and plating baths is unquestionably prejudicial to health, therefore the reader cannot be too particular in the matter of ventilation. A little liquid ammonia occasionally poured on the floor is advisable, especially in very hot weather.

64. In reducing old solutions by means of sulphuric acid, it must be borne in mind that the fumes are highly poisonous, and must not be inhaled in the *slightest* degree. The operation should be conducted either in the open air, or where there is a good draught to carry off the fumes. Beyond the current created by an open window and door, there should be no motion in the apartment, so that the fumes may be allowed to escape without being diffused. It must be remembered, however, that the fumes (consisting greatly of carbonic acid) are very dense, consequently it will be necessary to allow them to escape from the *lower* part of an apartment; they must not be expected to make their exit from an aperture *above* them.

65. In "colouring" gold of inferior quality, that is to say, below the English standard (18-carat gold), the *following mixture* may be used with success, and, if

carefully employed, even 12-carat gold may be coloured by it:—

Take

Nitrate of potassa (saltpetre)	4 ounces
Alum	2 „
Common salt	2 „

Add sufficient warm water to mix the ingredient into a thin paste; place the mixture in a small pipkin or crucible, and allow to boil. The article to be coloured should be suspended by a wire and dipped into the mixture, where it should remain from ten to twenty minutes. The article should then be removed, and well rinsed in hot water, when it must be scratch-brushed, again rinsed, and returned to the colouring salts for a few minutes; it is then to be again rinsed in hot water, scratch-brushed, and finally brushed with soap and hot water, rinsed in hot water, and placed in box-sawdust. The object being merely to remove the alloy, as soon as the article has acquired the proper colour of fine gold, it may be considered sufficiently acted upon by the above mixture. The colouring salts should not be used for gold of a lower standard than 12-carat gold, and even for this quality of gold some care must be taken when the articles are of a very slight make.

66. The process of hardening and tempering small steel implements, such as drills, scrapers, gravers, burnishers, &c., may be useful to persons living away from large towns; therefore I have thought it prudent to give an outline of the method to be pursued. The process of hardening and tempering will apply to any steel tool, of any dimensions, but we will take a small chisel as an example. The blade of the chisel should be removed from the haft or handle, and, the lower end

being held by a pair of pliers, the blade is to be placed in a brisk fire until red hot; it is then to be removed and allowed to cool for a few moments, and then dipped into cold water. The next thing to do is to file the blade into the required shape, finishing the filing with a smooth file. When this is done (a vessel of cold water being at hand), the blade is to be again returned to the hottest part of the fire, and allowed to become *white* hot, *i.e.*, as hot as a fierce fire will make it; and as soon as this is done withdraw it quickly with the pliers, and plunge it *instantly* into the vessel of cold water. If this has been done properly, on passing a file over the sharpened surface of the blade it will be found to have no effect upon it; in fact, the blade has become so hard that the file will not make any impression upon it. The upper surface of the blade should now be polished by rubbing it upon a sheet of emery-cloth moistened with oil, and then wiped with a piece of rag. The blade now requires to be *tempered, i.e.*, reduced in hardness. This is done by holding the sharpened *edge* of the blade with the pliers, and placing it in the fire until the polished surface of the steel changes colour. The surface nearest the handle will soon assume a blue colour, and an orange tint immediately following it, towards the upper end of the blade. At this point great care is required, or the instrument will be overheated and too soft; therefore, as soon as the orange tint makes its appearance within an inch of the sharp edge of the blade, withdraw it from the fire and examine it quickly; if the extreme edge is of a pale straw-colour, dip the blade *instantly* in cold water; but it must be understood that the straw-colour should be visible at *the extreme* point, or edge, of the tool. When such is

the case, the tempering is complete. The next process is to sharpen it upon a good Turkey stone, and it is ready for use. In hardening and tempering very small tools, such as drills, they may be more safely tempered by dipping them, point upward, in hot sand, by which means they are less likely to become over-heated. Some persons prefer dipping such tools into oil rather than water after removal from the fire; others, again, employ dilute sulphuric acid. It must be borne in mind, however, that in hardening steel the greatest heat is required in the first instance, and in the second, the greatest cold we can obtain. Upon these extremes, properly applied, depends the success of the operation.

67. A battery which has been somewhat commended it may be as well briefly to mention. It consists in using a saturated solution of bichromate of potassa, with a quarter part sulphuric acid, in the carbon cell of a Bunsen's battery (see p. 80); and dilute sulphuric acid, or saturated solution of sal ammoniac, in the zinc cell. Although this battery, or rather modification, has some advantages, it has yet to be further developed before it can safely be recommended for practical purposes.

68. A process of coating metals has been suggested by M. Weil, and for some purposes it may be employed with advantage. M. Weil's object is to avoid the use of cyanide of potassium and the battery, the first being deleterious, and the second expensive. His process may be briefly described as follows:—Instead of employing cyanide, he takes solutions of oxide of metals with the addition of organic matter—tartaric acid, albumen, or glycerine, to prevent the precipitation of the oxides by the fixed alkalies. A solution thus formed

may be used either hot or cold. For a coppering solution, he recommends the following formula :—

Sulphate of copper	350 grammes.
Dissolve in hot water and allow to cool . .	10 litres.
Crystallized Rochelle salt (potassio-tartrate of soda)	1,500 grammes.
Caustic soda (containing 50 to 60 per cent. free soda) *	800 „

The articles are to be suspended by zinc wires, or a thin strip of zinc may be attached to them when in solution; and when it is remembered that this process is independent of the battery, the solution will require renewing from time to time. To accomplish this, M. Weil proceeds as follows :—

The zinc which the solution has acquired must be precipitated by sulphide of sodium (prepared by fusing soda with sulphur) gradually, as an excess dissolves the precipitate formed by the sulphide of soda. When the zinc has been precipitated as above directed, the solution must be allowed to settle, and the clear liquor poured off. The solution is then to be resupplied with a solution of sulphate of copper, as before.

It is stated that copper deposited in this way adheres very firmly to iron.

Zincing by the above process is carried out by forming a concentrated solution of potassa or soda, which must be heated to 100° C., a piece of metallic zinc being placed in the solution in contact with the article to be coated.

True bronze, that is, a mixture of tin and copper, may be deposited by the above process, by adding to

* Caustic soda is prepared by dissolving 12 parts of ordinary soda in hot water, and then adding, gradually, 2 parts of lime recently slaked. The liquor should be boiled for an hour, and allowed to cool *and settle; the clear* liquor being decanted for use.

the copper bath before described stannate of soda or bichloride of tin, previously treated with the solution of soda. The metal to be coated must be in contact with zinc.

69. A new constant battery has been suggested by Mr. A. Reynolds, in which a solution of perchloride of iron is used as an exciting fluid, and metallic iron as the positive electrode.

70. Copper may be coated with antimony, as follows:—Dissolve 1 ounce protochloride of antimony (butter of antimony as it has been called) in 1 pint of spirit of wine; now add hydrochloric acid until the solution is clear. The article to be coated, being previously cleaned, will receive a bright coating in about an hour. Cast iron must be previously coppered by any of the processes before described, and will then receive a coating of antimony from the above solution.

71. As the refining of gold and silver is so closely connected with the electro-plater's art, the following hints may prove serviceable, it is hoped, to those unacquainted with the art of separating the precious metals from their alloys. An alloy of gold, silver, and copper, should be thus treated:—Suppose the alloy to be what is called "jewellers' gold," or the material with which cheap jewellery is made, and which, being unfit for use, is "only fit for the melting-pot." The alloy is first to be melted in a crucible with one-third of its weight of silver, a little dried potash or borax being used as a flux; when the alloy is well melted, it is to be poured into a vessel of cold water, which must be briskly stirred during the operation; and it is well to have a few small pieces of straw, or short sticks, floating on the surface of the water at the time, the object of which is to assist

the process of *granulation*. The alloy will now be found at the bottom of the vessel in small grains, which must be carefully collected, and in order to be certain that there is no waste, the alloy should be weighed before and after melting and granulation. With ordinary care scarcely any difference will be observed. The grains must now be put into a clean Florence flask, or other suitable vessel, and dilute nitric acid (1 part acid to 2 parts water) poured upon them: the grains should be allowed to digest for several hours; and, in order to promote chemical action, it will be advisable to place the flask upon a "sand-bath" or near the fire, but this may not be necessary until towards the end of the operation. The gold will now be found at the bottom of the flask, in the form of a brown powder or brown spongy lumps; but, in order to secure the entire removal of the alloys, it will be necessary to decant the solution of silver and copper in the nitric acid into a separate vessel, to be afterwards treated, and fresh nitric acid should then be poured on to the gold, and heat applied as before, to ascertain whether the alloys have been effectually removed. If *red fumes* are still given off in the flask, the separation has not been complete, and the action must be kept up until the red fumes cease to appear even at a boiling temperature. When this is the case, the acid solution must be again poured off, and the gold well washed with hot water, to remove any trace of silver or copper which may be in its interstices, especially if it is in a spongy form. At this stage the brown deposit or mass of gold is pure, and merely requires to be melted into a button with borax or potash.

The solution of silver and copper may next be

treated—the silver being thrown down by strips of copper; and, to ascertain whether *all* the silver has been precipitated by the copper, a small quantity of the solution may be placed in a glass, and a drop or two of hydrochloric acid or a solution of common salt applied; when, if any silver remains in solution, it will assume a milky appearance; if such is not the case, the cupreous liquor may be poured off, and the reduced silver well washed with hot water several times. The silver should then be dried and fused, a little dried potash being mixed with it previous to placing it in the crucible. The silver may then be granulated, as before, or cast in a mould of suitable size; and, being rolled out, will serve as an anode.

It must be understood that the above is but a trifling sketch of the principles of refining in the moist way; yet it is hoped that the reader will learn therefrom enough to enable him to pursue the art of separating gold and silver from their alloys for his own purposes.

When gold and silver are alloyed, or mixed with copper, brass, iron, &c., as in the case of jewellers' waste, filings, &c., the waste, being previously burned in an iron pan to destroy any organic matter present, should be well mixed with a little dried potash, and melted in a crucible. When perfectly fused, a few crystals of nitrate of potash (nitre of commerce) must be dropped into the crucible from time to time, which will remove from the gold and silver whatever copper or iron may be present, if sufficient nitre has been employed. The nitre must, however, be added cautiously; otherwise, if there be organic matter present, the flux may rise above the melting-pot, and, overflowing, carry part of the metal with it. It will be necessary to watch

the operation closely, and if the flux, &c., appear likely to overflow, a small quantity of dried common salt thrown into the crucible will check the ebullition, and tend to keep the metals and flux to the lower part of the vessel. When the operation is complete, the melting-pot or crucible must be withdrawn from the fire and set aside to cool. When cold, the pot must be broken at the base with a hammer, and the "button" of metal withdrawn. The button must now be again melted, as before described, with borax or potash, and granulated, the grains being treated as before, to remove the silver and copper.

As the above details are intended for the use of those who may be unacquainted with the art of refining, it is hoped that they may be found sufficient to enable the beginner to commence a study of a most interesting and important branch of industry.

72. Cyanide should seldom be added to a bath, whether of gold or silver, when the anode, being at work, is clean and uniform in appearance. It is always objectionable to have too great an excess of this salt in the bath; therefore it should never be added until the batteries and their connections have been well examined. Sometimes, when the battery is somewhat exhausted, the anodes become slightly discoloured, especially if a larger surface of goods is exposed than is proportionate to the surface of anode; in such case, it will be necessary to increase the activity of the battery rather than to add cyanide to the bath. Cyanide is a good friend, but a bad foe. All that a good bath requires is a slight excess of cyanide, if the battery is in good order and but little organic matter has accumulated in the bath. When, on the other hand, the bath

has acquired a good deal of organic matter (under which condition it is generally preferable to a new bath), it will require a greater excess of cyanide, and this excess, under such circumstances, will be very beneficial. An old or well-worked bath will bear a much larger amount of cyanide, in proportion, than a new one.

73. Old steel dessert-knives, which have been "close-plated," or solder-plated, as it is termed, will sometimes give the operator a good deal of trouble before he can deposit a sound coating of silver or gold upon them. Suppose the old silver has been stripped off, and the solder removed, the author has more than once found that a very serious difficulty has arisen when the articles have been coated either with gold or silver, or with copper, previous to coating with the other metals. For instance, a dozen dessert-knives, having been stripped and well cleaned, were placed in the alkaline copper bath. After an hour's immersion, the articles were removed from the bath and examined, when it was found that in every part of each blade, from heel to point, the blades were found to be *cracked*, exhibiting fissures in some cases nearly $\frac{1}{16}$th of an inch wide. These cracks pervaded each blade in almost every part, and it was some time before the cause of these remarkable flaws could be traced. In examining the interior of the cracks, it was found that the copper was freely deposited, and, the coating becoming thicker and thicker, the deposit of copper *forced open* the cracks (although at first invisible), until they assumed the alarming appearance we have described. It must be remembered that the numerous *points* which the fractured metal presented would *greatly* favour the deposit in those parts, in pre-

ference to the plain surfaces, and hence the opening of the invisible flaws in the metal as the deposit thickened. The same result has occurred in certain articles of wrought steel of bad quality; and when we bear in mind that the processes of grinding and polishing disguise such defects in steel, it must not be expected that they will show themselves until some time after deposition has begun. In order, however, to prevent, as far as possible, the flaws we mention from opening during deposition, we recommend that the first coating should be allowed to take place almost immediately after the article is immersed in the bath, and as soon as this is done, the article should be quickly rinsed, scratch-brushed, and returned to the bath. Again, it will be advisable to employ a tolerably weak bath at first, with good battery power, and after the articles have received a preliminary coating under these conditions, they may then be more safely allowed to remain in the bath until the required amount of metal is deposited.

74. When wooden vessels are employed for plating, they should be well saturated in boiling water for a few hours, or even days, before the solution of silver is poured in; as, independent of the absorption of silver by the wood, if it is well moistened with water, the interstices are not so readily acted upon by cyanide.

75. Gutta-percha vessels or linings of gutta-percha should never be used for a silver bath under any circumstances, as the cyanide acts upon gutta-percha and the adulterants with which it is always, more or less, contaminated. Nitrate of silver, also, acts upon gutta-percha, as most photographers are aware; and, therefore, it will be absolutely necessary to avoid using gutta-percha in contact with either cyanide of potassium

or nitrate of silver. I have known more than one instance in which a silver bath, being destroyed by a gutta-percha lining, has been reduced by sulphuric acid; and, soon after the acid has been applied, the gutta-percha has been set free, and has floated in the solution in clots of considerable size.

76. When the operator's hands have become injured by coming in contact with cyanide (which is frequently the case if there is an abrasion of the skin), it is a good plan to dip them for a few moments in very dilute sulphuric acid (20 drops in a tumbler of water), and then rinse them well. The hands should then be well soaked in tolerably hot water, well dried, and finally saturated with oil or grease of some kind. The author has frequently suffered from sores occurring under each nail of both hands, in consequence of neglecting to wash the hands immediately after immersion in a solution of cyanide. The electro-plater should be careful to avoid this, as sores thus formed are difficult to heal, and cause great pain to the part affected.

77. Copper or brass wire should never be bent or twisted more than once or twice without being annealed. When the wires used for slinging goods, or the wires proceeding from the electrodes of a battery, have been used more than once, they are apt to become brittle where they have been bent, and are liable to break; it is better, therefore, occasionally, to make the wires red hot, and, when cool, stretch them out by drawing them several times across the edge of a board, by which means they will readily become straightened. The wires should then be passed through a piece of emery-cloth, *to clean them.* The ends of slinging wires, however, *which have* become coated with silver, should first b

dipped for a few moments in the hot stripping solution (p. 56), and finally treated as above.

78. The moment the zinc plate of a battery evolves gas, accompanied by a hissing noise, the plate should be withdrawn and at once re-amalgamated; for, as soon as local action sets in, the current becomes greatly diminished; added to which, if allowed to continue, the zinc plate will soon be destroyed, without accomplishing its task. It is not uncommonly the case that local action begins on the first day that a battery is set in action; and, therefore, in order to remedy this defect as early as possible, the battery should be carefully watched, and the zinc plate removed the instant effervescence is observed in the battery-cell.

79. In order to ascertain whether an article is made of gold, if a doubt arises, a simple plan is to rub a portion of the article upon a piece of slate, Wedgewood ware or Turkey stone, and then apply a single drop of nitric acid by touching the part with the stopper of the bottle. If the acid produces no effect, the article may be considered gold. A very inferior alloy of gold, however (12-carat gold), will stand this test; but its colour will act as a guide, as it will fail (except when electro-gilt) to present the rich yellow colour of good gold. When a "common gold" article has been strongly gilt, it will be advisable to pass a keen but smooth file over a small part of the article, and then apply the nitric acid to the part, when, if the article is not genuine, the characteristic green tint of nitrate of copper will at once show itself. As it is commonly the practice to designate articles manufactured from "plated" metal (*i.e.*, gold and metal united and rolled out into thin sheets) "*fine* gold," the electro-gilder should make

himself acquainted, if he is not so already, with the various kinds of genuine and spurious gold in commerce; otherwise, should an accident occur to an article, he may lose more than he has a right to do; and, again, *plated* articles require a somewhat different treatment to that which is applied to articles of genuine gold. In applying the term "genuine gold," we suppose we must be understood to mean such articles as are made of an alloy of gold which *will* stand the test of nitric acid, if only to contradistinguish them from plated-gold articles. An instance once occurred to the author in which, by mistake, he placed two "gold" brequet or Albert chains in a jar containing nitric acid, instead of dipping them into a vessel of warm water, which stood beside it. Being away for an hour, on returning to the gilding-room it was found that the nitric acid had entirely removed all trace of the brequets, except a thin shell of one of the links, which floated upon the surface of the acid, and a dark-brown powder which had deposited in the vessel. On pouring off the acid, and washing the precipitate, which was found to be almost pure gold, it at once became evident that the so-called gold brequets (which had been invoiced at 55*s.* 6*d.* each, wholesale price) were, in fact, made of *plated* metal, but of so good a quality that a very good judge might readily have been deceived. The object of the above remarks is to place the electro-gilder on his guard. He should also endeavour to satisfy himself whether an article is really gold, or an alloy of gold, or plated, before preparing it for the bath, as, if it is gold, it will require as a rule a rather stronger current, and a larger surface of anode exposed in solution, than an article made of plated metal.

80. The back parts or hollows of casts, or "struck" work, will sometimes be troublesome to gild or silver, more especially because these surfaces must of necessity be kept at a distance from the anode, and besides which a concave surface (even if placed directly facing the anode) always receives the deposit more tardily than a convex surface. It will be necessary then, in order to aid the deposition upon the hollow surfaces, to keep the articles moved in the bath when first immersed, by which means all surfaces will receive the deposit alike, and the deposition which takes place after will be in the order required—that is, the outer surfaces will receive the greatest amount of metal, and the inner surfaces, or hollows, the least, but still sufficient for all purposes. If this precaution is not adopted, it is quite possible that the exposed surface of the article will be well coated, whilst the hollows will scarcely be coated at all. Nothing ensures uniformity of deposit so much as gentle motion in the bath, and in some manufactories an apparatus has been applied for keeping articles, while suspended in solution, in a constant but gentle state of motion—a practice very highly to be commended, upon principle, if it can be carried out with economy.

81. The effect of *motion* whilst an article is receiving the deposit is most clearly seen during the operation of gilding. If a watch-dial, for instance, is placed in the gilding-bath, and allowed to remain for a few moments undisturbed, if the solution of gold has been much worked, it is probable that the dial will acquire a dark red or "foxy" colour; but if it is quickly moved about, it instantly changes colour, and will sometimes even *assume a pale-straw* colour In fact, as we have before

observed, the colour of a deposit may be regulated greatly by motion of the article in the bath—a fact which the operator should study with much attention when gilding. In depositing brass from its solutions, the effects of motion are even more remarkable; for, by keeping the articles moved, copper alone will be deposited, whilst, on the other hand, if stationary, a proper alloy of copper and zinc will be obtained.

82. As there is always a deposit or sediment of some nature at the bottom of a bath, whether of gold or silver, the articles to be coated should never be immersed so deeply in the solution as to come in contact with this deposit. If spoons and forks, for instance, are allowed to reach nearly to the bottom of the bath or solution-vat, every time they are lifted up or lowered the small particles which had settled at the bottom of the vessel become disturbed, and resting upon the articles, will prevent the deposition of silver taking place wherever these particles are present, thus causing an irregularity of surface. As it frequently happens that small particles of silver fall off the surface of the anode, these will sometimes, if the sediment is disturbed, as we have pointed out, rest upon the lower parts of the work, and the deposit will take place *over* them, and when submitted to the scratch-brush the silver will strip or peel off; or, if the deposit is very thick, the bowls of spoons or prongs of forks, or such surfaces as are nearest the bottom of the bath, will be exceedingly rough, more especially as deposition always takes place more freely at the lower surface of the solution. There should, therefore, always be a certain distance between the lower end of articles in solution and the bottom of the *vessel in which* they are coated.

83. As pure silver is more easily oxidised, or tarnished, than standard silver, electro-plated articles should always be carefully protected from the atmosphere, especially if it be moist or vitiated. Electro-plated goods must always be kept well wrapped up, and in a perfectly dry situation; otherwise oxidation soon sets in, and the goods become unsightly and unsaleable.

84. Although a silver bath is improved by acquiring a moderate amount of organic matter, yet the operator should be careful not to suffer this accession to the bath to take place either too suddenly or in large quantities at a time. For instance, if candlesticks, which are sometimes filled with a compound of rosin or pitch, are placed in the solution without being previously freed from these substances, the cyanide will dissolve a considerable portion of the composition, and the conductibility of the solution is thereby lessened to some extent. In a moderate degree, the presence of such matter in a bath is an advantage; but it should never be allowed to enter the bath in large quantities at a time. A new bath which suddenly acquires a quantity of organic matter in the way we have described is apt to work sluggishly and with irregularity, and not unfrequently the deposit becomes coarse and spotted. On the other hand, a bath which in the course of several months has absorbed a small amount of organic matter (which will cause it to assume a dark-reddish colour) will give a much finer and brighter deposit than a bath newly made; and, at the same time, goods plated in it will be less liable to strip than when plated in a new bath.

The same observations do not apply to a gilding bath, *which is* generally worked hot, and, besides which, the

colour of the deposit is of the first importance. The presence of organic matter in a gold bath tends to deepen the colour; and if in great excess, the work will frequently assume a foxy-red tint, and this, in some cases, would be highly prejudicial. It is better, therefore, to keep the gold solution as free as possible from organic substances; and as one of the chief causes of a gold bath acquiring organic matter is the *imperfect rinsing of articles after scratch-brushing*, whereby the beer used in the operation of scratch-brushing becomes washed out of the interstices of the article when in the bath, it is advisable not only to rinse all articles well before gilding, but in fact they should always receive a final rinsing in perfectly clean hot water. It is not an uncommon practice for electro-gilders to rinse many articles, after being scratch-brushed, in the same water, and to transfer them directly to the gilding bath. Now this is highly objectionable: the water should be frequently changed, and when we consider the difference between investing a little trouble in renewing the rinsing water and making up a fresh gold solution, it will at once become apparent that the former will be most likely to yield an advantage. Again, a gold solution which has been worked a long time without becoming discoloured (the discoloration generally being due to organic matter) is far better than a new solution, and, for most purposes, will produce better results; but as soon as the solution becomes charged with the impurities referred to, its action is uncertain and irregular. It is to be hoped that the less practical reader will bear these observations in mind, that he may experience as little disappointment *as possible in his* operations.

85. As lead edges or mounts of cruet-frames, candlesticks, soy-frames, and similar plated goods are very troublesome to electro-plate, except in the hands of a very experienced person, it is frequently advantageous to adopt a plan commonly pursued, namely, to have the edges cast in brass or German silver, the old edges or mounts removed, and the newly-cast edges soldered upon the article. By this means all difficulty is removed, and the article, when finished, is not only rendered more durable, but can also be more highly finished.

86. It is a good plan for the operator to secure impressions in gutta-percha of all mounts, or parts of the same, which are likely to become serviceable to him at an after-time. These impressions can be electrotyped by the processes described in the early part of this work, and at any time castings can be made from them which may be applicable to many useful purposes. For instance, if an impression of a few inches of a gadroon mount be taken, and an electrotype obtained therefrom, and a few castings made from the electrotype, whenever the operator requires a few inches or even a part of an inch of such a mount, to supply the place of a broken gadroon edge, he will find the castings of great service to him. And by adopting this practice, it is possible not only to accumulate copies of very useful, but of many very choice mounts. And from these electrotype copies many beautiful and useful articles may be formed by carefully grouping the impressions obtained from various articles, or parts of them, to form a new design of an entirely novel character. The author has produced some very pleasing effects by arranging alternately, for instance, a *piece of scroll*-work an inch and a quarter in width,

and a cornucopia of equal width, the latter being about two inches long. Four impressions of each being taken, and soldered together, formed a handsome octagonal salt-cellar. A circular ring of wire, connected by short pieces of wire to the inner surface of each "upright," formed a resting-place for the glass or salt vessel, which may be made either of blue, red, or white glass, according to taste. From the above hints the reader may glean sufficient to enable him to construct, upon the same principle, many articles of great beauty, and at the same time possessing novelty of construction, if not of design. Impressions of very rare subjects may be taken and applied in this way, and there is scarcely a limit to the variety of effect which may be produced.

87. A very pleasing effect may be produced upon a plain silver article, by sketching a design upon it with a good lead pencil—a name or initials, for example—and if the article is then placed in the gilding-bath for a few moments, all parts which have not been traced by the lead pencil, will have become gilt. When the article has been rinsed, gentle rubbing with the finger will remove the plumbago, or "black lead," and beneath the design will appear in silver. By reversing the operation, the design may be made to appear in gold. Plumbago answers well for this purpose, owing to its being an inferior conductor to either gold or silver, especially in alkaline solutions. In practising this process, however, care must be taken not to move the articles while in solution, otherwise the plumbago may be worked off by friction, and, consequently, the design will be obliterated by deposition taking place where the design appeared.

88. *When several articles made of different metals*

are to be plated in the same bath, the article which is the worst conductor should be put in first. Thus, supposing copper, brass, and German-silver articles are to be immersed, the copper article should be suspended first, the brass next, and the German silver last. At the same time, the anode must be slightly lowered as each article is suspended. If convenient, it is better to plate articles composed of one metal or alloy only, at the same time.

89. Bichloride of mercury in solution has been recommended for amalgamating zinc plates instead of the ordinary method, and, in many respects, it would appear to present an advantage. But if zinc plates are cast from a mixture of zinc and mercury, they would be still more effective and durable, and less liable to local action. The alloy of zinc and mercury consists in melting zinc in the ordinary way, occasionally adding a little grease, rosin, or sal ammoniac, and, when melted, pour in gradually mercury in the proportion of—1 ounce of mercury to each pound of zinc. Zinc thus alloyed is exceedingly brittle, and the plates will therefore require careful treatment. If well prepared, however, these plates possess many advantages over the ordinary amalgamated plates.

90. All old plated articles which have to be pumiced or rendered smooth with Water-of-Ayr stone, or otherwise prepared for plating with the aid of water (that is to say, not being rendered smooth by emery-cloth, &c.), should have a vessel kept specially for them; for instance, a wooden tub with a board placed across, in order that the particles of silver rubbed off by the pumice, &c., may be collected in the vessel beneath; *and the electro*-plater cannot be too careful in saving

this and all other kinds of waste, either of gold or silver. Many persons who have omitted to save this kind of waste from the commencement of their operations have nurtured the idea that it was useless (having lost so much already!) to begin to save such comparatively trifling waste; but we would strongly impress upon the student the great importance (when dealing with the precious metals) of using the utmost economy. Gold and silver are always recoverable, in some shape or other; therefore, to allow them to escape down a gutter beyond the power of recovery (as many photographers do) is not only foolish, but wicked.

91. A good conducting surface may be given to gutta-percha, wax, or other non-conducting material used in electrotyping, by employing precipitated silver. This may readily be formed thus: Make a solution of nitrate of silver, and place in it a few pieces of clean sheet zinc; in a few hours the silver will be thrown down in the form of a grey powder. Any silver which may adhere to the zinc can be easily brushed off. The precipitate (which is fine silver) must be well washed with hot water, and then carefully drained on a filter of blotting paper; it is then to be well dried at a gentle heat, when it is ready for use, and may be employed in the same way as plumbago.

92. Any good metallic bronze, but more especially copper bronze, will form an excellent conducting surface on gutta-percha or wax. The bronze known as Bessemer bronze is admirably suited to this purpose.

93. Copper ribbon may be advantageously substituted for copper wire, more especially when large electrotypes have to be formed.

94. When a mould presents many hollows or cavities

it is advisable to employ "guiding wires," as they are termed, to aid the deposit on these surfaces. For instance, a bunch of thin copper wires may be twisted round the negative electrode, close to its junction with the mould, and these wires should then be bent and allowed to touch each hollow or cavity, so as to favour the deposit at those parts. A very little practice will soon make the operator skilful in this matter.

95. A very good alloy for zinc bars (for battery purposes) may be made by putting half an ounce of quicksilver to each pound of zinc in the crucible. The zinc bars should be well amalgamated all over before using, and they will retain their uniformity for a considerable time without any further application of mercury.

96. It has been suggested to melt wax and litharge (oxide of lead) together to form a good composition for electrotype moulds. Take 1 pound of wax, and 1 ounce of litharge; fuse them in a pipkin for half an hour; then allow the litharge to subside, and pour off the clear liquid and set aside to cool until wanted. This composition is supposed to be less liable to contract when passing from the fluid to the solid state.

97. When the "single cell" arrangement (*vide* p. 14) is employed for electrotyping, a stronger solution of sulphate of copper may be used than that before described. For instance, take $1\frac{1}{4}$ pound of sulphate of copper, half a gallon of hot water, and dissolve. Then add 1 pint of cold water acidulated with 4 ounces of sulphuric acid. The solution should be allowed to stand for some hours until quite cold, and the clear liquid separated from any sediment that may be present, *when it will be* ready for use.

98. When fusible metal is employed for making moulds, care must be taken that the ingredients with which it is composed (p. 25) are well blended together. This is best secured by re-melting the alloy several times. When first melted, pour the alloy in detached globules on an iron slab, or a piece of slate will do, and when cold re-melt them. Do this several times to ensure perfect mixture.

99. When a very stout deposit of copper is required for an electrotype, copper filings may be sifted over the deposited metal (provided the deposit is perfect), and the electrotype is then returned to the bath to receive an additional coating. The deposit will unite with the copper filings, when fresh filings may be added again and again, the mould being placed in the bath each time until the required thickness is obtained.

100. Instead of adding sulphuric acid to the saturated solution of sulphate of copper as described at p. 15, Glauber's salt (sulphate of soda) may be substituted. Take, say, saturated solution of sulphate of copper 2 parts, Glauber's salt 1 part, dissolved in sufficient cold water. The two solutions are to be well mixed together.

101. There are few articles with which the electro-metallurgist has to deal that are sold in a less pure state than the ordinary cyanide of potassium; and in order that he may be able to estimate the money value of commercial cyanide, we give the following method suggested by the late gifted Thornton Herapath, of Bristol:—*

"The first thing to be done in testing cyanide of potassium is to prepare a standard solution of ammonio-

* *The Chemist*, vol. iii., p. 385.

sulphate of copper or ammonio-nitrate of copper. A certain known quantity of pure crystallised sulphate of copper, made by crushing the pure crystals of the shops in a mortar and pressing the powder so obtained between folds of bibulous paper, is taken and dissolved in water. The solution so prepared is then to be diluted with water so as to measure 2,000, 3,000, or more water grain measures at 60° F. Supposing 390·62 grains of the pure sulphate to have been taken and diluted to 2,000 grain measures, every 100 grains of such solution will, of course, represent 5 grains metallic copper, or 6·25 grains of the protoxide of copper; 100 grains of each of the samples of cyanide of potassium to be tested are then dissolved in a sufficient quantity of water, and introduced into the colorimeters; an excess of ammonia is added, and the standard solution of copper is carefully added (out of a graduated burette) to the contents of each colorimeter in turn, until a faint blue coloration makes its appearance in each of the solutions. The quantities of copper, or of the solutions taken, then indicate the relative strength and money value of the samples of cyanide examined. Suppose, for instance, one specimen took 100 measures, and a second 150 measures of the copper solution, the relative strengths and values of such specimens are, therefore, as 100 to 150, or 2 to 3."

In order to render the above process available in the determination of the actual strength of, or proportion by weight of pure cyanide of potassium existing in the commercial cyanides, it is only necessary to obtain a small sample of *pure* cyanide and to ascertain how much of this is required to decolorise 1 grain of copper *in the form of* ammonio-nitrate.

102. To those who use jewellers' rouge (red oxide of iron, or *colcothar*) in large quantities, and to whom its extreme fineness is of the first importance, the following process for its manufacture will be found highly serviceable. By the ordinary methods of making rouge much care is required not only to free it from acid, but also from hard particles which would be highly injurious if not effectually separated from the article in the process of manufacture. To M. Vogel, jun., of Munich, we are indebted for the process referred to, which is not only simple but certainly effective.

Into a solution of sulphate of iron made with boiling water and filtered, pour a concentrated solution of oxalic acid, until no more yellow precipitate of oxalate of protoxide of iron is formed. When the liquid is quite cold, and deposits nothing more, the precipitate is washed on a cloth with hot water until the washing water no longer gives an acid reaction upon blue litmus paper. The oxalate is afterwards well drained, and heated in the partially dry state on an iron plate or in a boiler of the same metal, over a small charcoal fire or even a spirit lamp. The decomposition commences at the temperature of 392° F., and on raising the temperature a little the red oxide of iron is formed, and is found in the finest possible state.

The rouge thus formed affords the most perfect security of the finest division of the product, and may be employed with the greatest success in polishing either gold or silver, and it has been found invaluable in the polishing of plate-glass, Daguerreotypes, and optical instruments.

103. M. Vogel, jun., also turned his attention to the *substance* known as "putty powder" (oxide of

tin), which he prepares by the following simple process:—

A solution of commercial chloride of tin is prepared by pouring on 1 part of the salt 6 parts of boiling distilled water, and the solution is filtered through a cloth into a cylindrical glass vessel in order to keep back any foreign substances with which the chloride may be contaminated. Into the still hot and almost clear solution of chloride of tin is poured a concentrated solution of oxalic acid; a white precipitate of oxalate of protoxide of tin is formed. After complete cooling, the liquor is decanted, and the precipitate washed on a linen cloth with cold water until the washings no longer give evidence of the presence of acid on litmus paper.

The oxalate of tin is now to be heated, dried on an iron plate, or in a boiler of the same metal, over a small charcoal fire. The decomposition of the salt commences at red heat, and there remains; after the disengagement of carbonic acid gas and carbonic oxide, a quantity of oxide of tin is found in a state of extreme division.

During the decomposition—which must be accelerated by stirring with an iron wire—the matter undergoes a considerable increase in bulk; consequently, it is necessary to employ for this operation very spacious vessels, so as to avoid loss of product.

With regard to quantity, we obtain 1 part of oxide of tin by employing 2 parts of chloride of tin and 1 part of oxalic acid.

It will be obvious that by the above processes each of *the products* will be in the form of an impalpable *powder, which* is of the greatest importance in polish*ing metallic* surfaces.

104. Electrotypes may be bronzed by suspending them in a wide-mouthed bottle, at the bottom of which a small quantity of sulphide of ammonium has been placed. The sulphide of hydrogen which escapes will give a good bronze tint to the copper in a few moments, the depth of tone being regulated by the time of exposure.

105. A very good elastic moulding material for copying objects which are very much *undercut*, may be made by dissolving 1 pound of gelatine in three-quarters of a pint of water, over a slow fire; when dissolved, add half an ounce of beeswax cut up in small pieces. This mixture should be warm, but not hot, when used. Before applying elastic moulding materials plaster casts should always be carefully brushed over with oil.

106. Glass vessels may be coated with copper by the electrotype process, by simply varnishing the outer surface of the vessel, and when the varnish is *nearly* dry, brushing plumbago well all over it. A conducting wire is then attached to the varnished surface, which may be conveniently done by employing a small piece of softened gutta-percha or beeswax—taking care to apply the plumbago to the part which unites the wire to the plumbagoed surface.

107. In no case should an electrotype be removed from the mould until a sufficiently stout deposit has been obtained, otherwise the operator may be disappointed by finding the copy break while he is separating it from the mould.

108. It is a good plan to allow amalgamated plates of zinc to dip into a shallow vessel containing mercury; this vessel should be placed at the bottom of the battery jar, and the plate allowed to rest in it while the batte-

is in action. This will keep the plate well amalgamated for a long period, if the process of amalgamation has been efficiently carried out in the first instance. The evolution of gas at the plate will always indicate when undue chemical or "local" action takes place, when the plate should be at once removed and re-amalgamated.

109. Decomposition troughs for electrotyping may be very conveniently made by those who live in districts where chemical apparatus is not easily obtainable, by the following plan. Obtain four pieces of plate glass, say two pieces 12 in. × 6 in., and two pieces 8 in. × 6 in. These plates of glass may be readily united by Canada balsam, melted gutta-percha, or marine glue —the two shorter plates being so placed as to form the ends of the vessel. A piece of stout board, 13 in. × 9 in., forms a bottom, and the glass vessel may be cemented to this first with Canada balsam, and lastly by pouring melted pitch or asphaltum round the interior of the vessel, where the glass and wood unite. Softened gutta-percha, fused on by means of a moderately-heated poker, will be a very secure and simple substitute for the pitch. A glass vessel thus constructed will last for years with moderate care, and is admirably suited for electrotyping purposes. Plating solutions containing cyanide of potassium, however, should not be placed in vessels which are made of detached materials, as the substances employed to put them together are generally soluble in cyanide, not excepting gutta-percha. In a vessel of the size above given, several electrotypes may be made at the same time with a battery of tolerable power. When several electrotypes are to be produced in the same decomposition trough, the moulds should b

suspended from a brass or copper rod connected with the negative pole of the battery, and a stout sheet of copper (connected with the positive pole of the battery) is to be suspended in the copper solution immediately facing the moulds to be copied.

110. When the mould is first placed in the solution of copper, only a *very* small surface of the copper anode should be immersed at first—a surface about equal to the amount of wire attached to the mould which is in solution. This precaution will prevent the deposit taking place too rapidly at the junction of the wire with the mould—a very important matter to avoid, since otherwise, the copper might become deposited in the state of a powder instead of in the proper reguline condition. And, again, the battery power must not be too vigorous at first, or the deposit will take place too rapidly at the point of the wire, assuming a dark-brown colour of a powdery texture. When the deposit has commenced properly, a bright red layer of copper will start from the point of the wire, radiating gradually on to the plumbagoed surface. After a while, the anode may be lowered gradually, thus augmenting the surface *in solution* as the deposit progresses. When the mould is thoroughly coated the battery power may be increased, and the surface of anode in solution augmented also.

111. Those who are unable to procure porous cells of any given size at a time when they are most in need of them, may render themselves independent in this respect by manufacturing these things for their own use by a *very simple* method. For this purpose, a bag of coarse *plaster-of-Paris*, a thin sheet of tin, or a sheet of paste-*board*, a wooden core, and a little string are all th

will be required. Having determined what size the porous cell is to be made, a round wooden roller (such as silks are rolled upon, and which may be obtained from any linendraper) is procured, and this is to be employed as a *core*, thus:—Make an artificial shoulder, say 12 inches from one end of the roller, by binding about six strips of thin card, one above another, round the roller. These pieces of card should be about an inch in width, and each succeeding strip or layer must be cut longer as the circumference increases, so as to form a perfectly round shoulder. A piece of thin sheet tin or pasteboard, say 13½ in. long, is now to be tightly bound round the shoulder, to form a tube or case, and the edges of this outer case may be further closed by sealing-wax—taking care that the roller does not touch the outer case. In order to render the core easy to remove, the wooden core may be covered with a layer of foolscap paper, pasted at its edges and overlapping the end; the paper should be well oiled. The mould being now ready, a sufficient quantity of plaster-of-Paris is to be worked up *quickly* into a thin paste, and, the mould being inverted, the plaster is to be carefully but promptly poured in, taking care that there are no air bubbles, and that the plaster reaches the extreme open end of the tube, which is to form the bottom of the cast. When all the plaster is poured in, the mould should be held upright until the plaster has "set," which it will do in a few minutes. It may then be put aside for an hour or so, when the core may be withdrawn, gently, and the outer case removed. Should the paper in which the case was enveloped still remain in the mould, this may be easily removed by gently *pulling it away*; or, should it prove obstinate, when

the porous cell has become *quite hard* a little hot water and soda will soon render it easy to remove, by converting the oil into soap and the paper into pulp. The porous cell should then be rinsed, and after trimming its rough edges with a knife or file, the cell is ready for use. By shifting the shoulder, porous cells of more or less depth may be made at any time. A little practice will soon render the operator expert in porous cell making.

112. In coating steel or iron articles with nickel, deposition should not be allowed to take place too rapidly at first, otherwise the metal will be liable to strip. The battery power should be moderate, and the surface of anode in solution only sufficient for the deposition to take place at once, but not too vigorously. When the articles have become "struck," as it is termed, the strength of the current should be gradually but cautiously increased from time to time. This must be done with judgment, however, as a good reguline deposit of good colour depends greatly upon the nature of the current employed and the amount of anodal surface exposed. It is also of the greatest importance that articles of steel or iron should be placed in the solution-bath *immediately* after they have been cleaned, as even a few moments' exposure to the air, or immersion in water is quite sufficient to cover them with an invisible layer of oxide, which would prevent the nickel from adhering closely to the other metal. On the other hand, it is important in coating steel or iron articles with nickel, not to suffer deposition to take place too slowly when they are first placed in the bath, as they are apt to strip from this cause also. When convenient to do so it is a good plan to scratch-brush the

articles after they have received a thin coating, by which the subsequent deposit is rendered far more liable to adhere. The author has always found, when coating either steel or iron with other metals, that the scratch-brush has been his best friend; and the labour bestowed has given ample return in the shape of a good adhesive coating to these rather refractory metals.

113. When precipitating zinc or copper by sulphide of hydrogen from acid solutions of nickel, as, for instance, in cases where commercial, and not pure, nickel has been used, it is of the greatest importance to observe two essential conditions of the liquid treated. 1. If the acid solution contains a large excess of acid, it is exceedingly probable that a small portion of zinc will continue in solution even though the stream of sulphide of hydrogen may have passed through the solution for several hours. 2. If the acid solution is highly concentrated, it will be almost impossible to get rid of every trace of the zinc. The conditions which most favour the *complete* separation or precipitation of the zinc are, the solution being only moderately acid, and tolerably dilute. Copper is more readily thrown down by sulphide of hydrogen than zinc, and the absence of its characteristic colour is sufficient evidence that there is none of this metal in solution. The sulphide of hydrogen, whilst it leaves the nickel in solution, will readily precipitate either antimony or iron, should the nickel have been alloyed with either of these metals; but the solution must be slightly acid at the time, otherwise the nickel also will be thrown down.

114. Britannia metal, or pewter articles which are to be coated with nickel, require different treatment to *either brass,* steel, or iron. Being inferior conductors,

these softer alloys require vigorous battery power in order to induce the deposit to take place promptly. At the same time it is advisable, *provided the deposit takes place immediately after immersion*, to move the pewter or Britannia metal about in the solution gently, so as to ensure a uniform coating, and to prevent the deposition taking place too suddenly. Of course this will only be necessary when very strong battery power is employed. After awhile, that is when the articles are completely coated with nickel, they may be allowed to remain in the bath to acquire the necessary thickness of coating without being disturbed beyond an occasional shifting of the suspending wires.

115. It is a good plan, when a large number of Britannia metal articles have to be coated with nickel —especially if the bath is not in a favourable condition —to give such articles a slight coating of brass, by employing either of the solutions described in the earlier part of the work. After being coated with brass, the articles must be well rinsed in clean water, and at once transferred to the nickel-bath.

116. The solution for nickeling steel or iron should not be quite so strong as that used for brass or copper.

117. Zinc is more readily precipitated by sulphide of hydrogen from the solution of its chloride, than from the solution of sulphate, though both will yield up their zinc to the sulphide if the conditions referred to in § 113 are fully carried out.

118. Sulphide of hydrogen may be readily made as follows:—Take, say 1 lb. of iron filings, and intimately mix with them about 4 ounces of powdered sulphur, place this in a crucible and subject to a good heat in a coke fire. When red-hot, the crucible may be set aside to

cool, and the sulphide of iron formed may be bottled until required for use. To generate sulphide of hydrogen gas for the various purposes referred to in these pages, put a little of the sulphide of iron in a wide-mouthed bottle fitted with a cork in which a hole must be bored to admit a glass tube to convey the gas. This tube should be bent to the shape given in the woodcut, by holding the part to be bent over a gas-burner or spirit-lamp. When the glass becomes red-hot it will readily bend, and should be allowed to cool gradually. This tube is now to be placed in the perforated cork, the shorter end being inserted and allowed to project about half an inch beyond the cork. Now add about 4 ounces of cold water and 1 ounce of sulphuric acid to the sulphide of iron, place the cork firmly in the bottle, and *at once* put the long end of the tube in the solution to be operated upon. It is well to state that sulphide of hydrogen, besides being very offensive to the organs of smelling, is exceedingly poisonous when inhaled; it is advisable, therefore, when employing it, to use every precaution, and, if possible, to conduct any operation in which it is used in the open air. The sulphide of ammonium may be formed by passing the above gas through a dilute solution of liquid ammonia, and this must be kept in a stoppered bottle.

119. A method of nickeling small articles, such as pins, hooks and eyes, &c., by boiling, has been suggested by Dr. Kayder. He first melts together 1 part copper and 5 parts pure tin. The alloy is granulated in the usual way, but not too fine, and then mixed with

water and cream of tartar into a paste. To each two hundred parts of the granulated alloy is added one part ignited oxide of nickel, and the articles laid in the mixture. After boiling a short time, they are said to become well plated. Some fresh oxide of nickel must of course be added from time to time. Brass and copper articles can easily be plated in this manner without previous preparation; those of iron must first be copper-plated. By adding some carbonate of nickel to the above bath, or to a common white bath, and boiling, a coating richer in nickel is obtained.

120. A very good solution for electro-brassing may be thus made:—In a vessel capable of holding, say 10 gallons, put 5 gallons of water and 1½ lb. of cyanide of potassium, which must be allowed to dissolve; next add 2 lbs. liquid ammonia, and 5 lbs. carbonate of potassa; then half fill a large porous cell with a strong solution of cyanide of potassium, and in this solution immerse several pieces of thin sheet copper. A sheet of milled brass is now to be soldered to the positive pole of the battery, and this is to be immersed in the larger solution of cyanide, &c. The negative pole of the battery is to have a piece of thin sheet copper soldered to it, and this is to be placed in the porous cell, in close contact with the other pieces of copper, and the porous cell is to be placed erect in the larger bath. The solution of cyanide should be of the same height in each vessel. The battery is now to be allowed to continue in action until there are about 15 to 20 ounces of brass dissolved into the solution from the sheet of brass—the exact weight of which should be ascertained before and *after immersion.* When the full amount of brass is *dissolved,* the porous cell is to be removed and water

added to make ten gallons of solution. With one or more Bunsen's batteries, the above solution will give very good results. Fresh cyanide and liquid ammonia will have to be added from time to time, when the solution ceases to give good results. If at any time the solution becomes tardy in its action, it is a good plan to add to it a certain quantity of concentrated solution made as above. In fact, it is well to keep in stock a supply of concentrated solution with which to strengthen the bath occasionally, for the brass anode seldom dissolves freely enough to keep the solution at its normal strength.

121. Timepiece dials which have been plated by the chloride of silver process—that is, the old-fashioned method of plating—may be replated by the same process, if required, in the following manner:—Dissolve a small quantity of silver in nitric acid, and then dilute with water. Pour in a strong solution of common salt, which will throw down all the silver in the form of chloride. Wash the precipitate thoroughly with warm water, finally pouring off the whole of the water. Add a little common salt, powdered, to the chloride and work up into a paste. Having well cleaned the dial—which is made of brass—the paste is to be rubbed on its surface with the flat end of a good cork. By rubbing the paste on, in circles, a smooth layer of silver will be given to the dial which will retain its colour for many years. The operation of rubbing on the chloride paste must be conducted with *great* care, in order to ensure perfect evenness. After *the dial is* well coated, it is to be rinsed in hot water *and dried,* when it may be gently rubbed with cotton *wool. It is* then ready to be repainted.

122. The most economical way to gild gold chains, &c., which are merely required to be "coloured"—that is, to have a slight coating of fine gold of good colour upon them—is first to well scratch-brush the articles, being careful to let the beer run freely, and then give them a momentary dip in a hot solution. The battery should be in good working order, and a good surface of anode exposed. When this operation is well conducted, although the work will exhibit the colour of fine gold, there will be so small a quantity of metal deposited that its weight would scarcely turn the scale. This applies mostly, however, to articles which are made of a good quality, say 16 or 18 carat gold. When the goods are manufactured of a lower standard a superior coating should be given. Many articles made of 18-carat gold, which have been frequently "coloured"—that is, boiled in the colouring salts—become so tender from the alloys of silver and copper having been partially removed from them, that it is frequently advisable to electro-gild them rather than run the risk of colouring them in the ordinary way. The author has frequently met with chains, &c., which would scarcely bear handling, from having been coloured a great many times. It is necessary to be very careful in scratch-brushing such tender work, as breakages become very embarrassing to the electro-gilder. Only the extreme points of the scratch-brush should be employed, and very light pressure given.

123. All kinds of wire-work, but more especially *filigree-work*, require to be coated in a solution *containing a fair* amount of gold. The battery should be *vigorous*, and a good surface of anode exposed. Unle

these conditions are observed, wire-work is liable to receive the deposit partially. When the current is tolerably strong, if the articles are gently moved about while in solution, those parts which are most difficult to gild will more readily receive the deposit; and when once the article is coated all over the deposition will proceed with greater uniformity. It is a good plan, however, to scratch-brush the articles as soon as they have become coated, and then to immerse them in the bath until finished.

124. The insides of cream-ewers, mugs, &c., should never be gilt with an anode which is thin and much worn at its lower edge, otherwise small particles of gold will fall from the anode, and becoming deposited on the bottom of the vessel, these particles will prevent the deposit of gold taking place at the parts on which they have rested. When the anode is thin and ragged, from long use, it is better to cut away the ragged portion before employing it for insides of sugar-basins, &c. A stout anode is, of course, preferable to a thin one, but with the precautions we have suggested the latter will answer very well. A cylindrical anode is better than a flat one for the insides of vessels, inasmuch as it causes the deposit to take place more uniformly—especially in the hollows of chased work.

125. In cases where it is not desirable to remove the tin from the bottoms of old cruet-frames, the tinned surface may be coated with a thin layer of copper by simply applying a sponge dipped in a weak solution of sulphate of copper, to which a few drops of sulphuric acid may be added; and by touching the part *to be coated* with a thin strip of clean iron or zinc, the

tin will become instantly coppered wherever the sulphate of copper has touched it. Thus part at a time may be coated with copper, and when the entire surface is coated, the article should be rinsed and then properly prepared for the plating-bath.

126. Sometimes a plating-bath, unless it be very deep, will give a rough deposit upon the lower surface of large articles, such as salvers, dishes, &c. The reason of this is that particles of dust, which had settled at the bottom of the plating-bath, become disturbed when an article of large size is immersed, and these particles settling upon the article cause the deposit to take place irregularly, and in a rough state. Not only this, but when the anodes have been long in use, and have become much worn at the lower edge, minute particles of silver fall to the bottom of the bath, and when the solution is disturbed by immersing an article of large surface, those particles of silver will settle upon the lower part of such articles, and the deposit will take place *over* them, causing a very rough and streaky coating, which it will be very troublesome to render smooth enough for the burnisher. The streaky form of deposit from this cause always assumes a vertical direction. To remedy this defect, the best plan is to let the solution rest for twenty-four hours, and then carefully draw it off by means of a syphon to within a few inches of the bottom. The remaining portion of the solution should be carefully filtered and then added to the bulk. Some careless persons have been known to rub the suspending-rods with emery cloth while they have been lying across the bath. This should never be done, as the particles of brass, emery, &c., would *most* certainly prove injurious in the way

we have stated at some time or other—independent of the fact that the cyanide will act upon small atoms of oxidised brass, and thus impair the solution.

127. When a battery has been used for some time and it works slowly, it is better to throw away the contents of the cell, which will be strongly impregnated with sulphate of zinc, than to keep on adding fresh acid. An accumulation of sulphate of zinc not only retards the action, but it also prevents the acid from doing its duty properly. If there is a large excess of sulphate of zinc formed in the battery cell, it will even crystallise upon the positive element, and thus stop the action of the battery altogether.

128. Batteries should never be in alternate pairs when used for depositing gold or silver, as this intensity arrangement is apt to decompose the solution, besides rendering the work liable to strip. It is better to unite all the wires issuing from the copper into one group, and those proceeding from the zinc into another group. By doing this, the quantity of the current is increased without increasing the intensity (*vide* p. 141).

129. A form of battery designed by the author many years ago may prove of service to the electro-gilder, and therefore a brief description of it may not be unacceptable. A long strip of sheet copper is to be corrugated (as in the annexed engraving), to which a copper wire is attached; this is placed in a cylindrical jar; a stout zinc bar, amalgamated, and with copper wire cast into it, is placed in a porous cell. Dilute sulphuric acid is used as the exciting fluid for both metals.

By corrugating the sheet copper a much larger surface is presented than when a plain copper cylinder

is used, and thus the quantity of the current is augmented.

An easy way to corrugate the sheet copper is to be provided with two round sticks, say half-an-inch in diameter and twelve inches long, and by rolling the copper half-way round one stick, which is placed *on* the copper, and the other stick *under* the sheet, which is then bent half round the second stick. The first stick is then withdrawn and placed on the metal as before; and so on until the entire strip of copper is equally corrugated or fluted. Care must be taken to have the strip of copper of sufficient length to admit of its receiving the requisite number of turns to form a cylinder, and of the required width. The strip of copper must be about three times the length that would be required for a plain cylinder for the negative element.

130. M. Klein, of St. Petersburg, has succeeded in making electrotypes in iron as a substitute for copper electrotypes, and it is said that the improvement has been eminently successful in its application to bank-note printing, &c. After having tried many solutions of iron, but with only partial success, M. Klein at last found one which answered his purpose thoroughly. This bath consists of a solution of sulphate of iron, from which the iron is precipitated by carbonate of ammonia. The precipitate is then dissolved in sulphuric acid. The solution must be evaporated to expel any free acid. Another bath consists of equal *parts of chlorate* of ammonia and sulphate of iron. *Both these* baths must be used as concentrated as pos-

sible. An iron anode is to be employed exposing about eight times more surface than the copper cathode which is to be coated presents. After being worked some time, the deposit became faulty, which was found to be due to the presence of acid in the bath. This acidity was proved to be due to the anode not supplying the solution with the proper equivalent of iron to replace that which had been deposited. M. Klein then introduced a copper anode, as well as an iron anode, and the bath soon became neutral again, and the deposition was more uniform. [The surface of anode *must* be extensive.] The colour of the deposit was a dull grey, and somewhat rough, probably owing to the air-bubbles formed during the process. The metal deposited was exceedingly hard, being nearly equal to hardened steel. When heated to cherry redness it became malleable, and as easy to engrave upon as soft steel. The electrotype plates thus formed are said to be very durable—far more so than copper, and hence their importance in bank-note printing. The deposited iron is permanently magnetic. Doubtless M. Klein will improve upon his present process in course of time, but so far it appears to be a perfectly practical process—at least, in his hands—and the Russian Government have promptly turned the invention to account.

131. Electro-etching is another useful application of the art which is worthy of notice. A copper plate is prepared in the same way as for engraving; it is then to be coated with a mixture composed of asphalte, wax, pitch, and Burgundy pitch; and the back of the plate is to be varnished. The design is *now to be* drawn through the etching-ground with

a fine point. When this is done, attach the plate to the positive pole of the battery, and immerse in a solution of sulphate of copper or dilute sulphuric acid —using a second plate of copper for the negative pole. After a few minutes' immersion, remove the prepared plate, dry it and stop out the fine etched lines with varnish. The shadows are next to be traced through etching-ground, in the usual way, and the plate again placed in the bath for a few minutes. Each time after the etching-point is used in the various stages, the plate is to be returned to the bath for a few minutes, and the etching-lines stopped out with varnish as before. When the last touches have been given, the plate is to be immersed in the bath as before, and finally the etching-ground and varnish removed, when the plate will be ready for printing.

132. Gutta-percha and wax models for electrotyping may have their surfaces rendered conductible by the following plan :—Take equal parts of albumen (white of egg) and a saturated solution of common salt, and apply the mixture to the object to be coated by means of a soft brush. Then dry the composition thoroughly. Now make a strong solution of nitrate of silver and dip the mould into it for a few minutes or so, and again dry. Expose the mould to a strong light, until it becomes quite black. The mould is then to be dipped into a saturated solution of sulphate of iron, when a layer of metallic silver will be formed, upon which a deposit of copper may readily be obtained. The mould should be rinsed when taken from the sulphate of iron solution, and the battery wire attached to it, when it may be at once placed in the electrotyping bath.

133. The sulphate of iron combined with sulphate of ammonium has been recommended to form a solution for depositing iron upon copper surfaces, such as copper engraved plates, &c. Iron being much harder than copper, it is much desired to obtain a good reguline deposit of this metal upon engraved plates, by which their durability is considerably enhanced.

134. Becquerel recommends (in order to prevent the formation of peroxide of nickel in the nickel-bath) the continual addition of ammonia, by means of which the acid which is set free becomes neutralised. When the anodes fail to supply the solution-bath with the amount of nickel taken from it by the articles coated, acid is liberated, and an inferior deposit is the result. It is important, therefore, to keep the solution neutral *constantly* by the addition of ammonia, a moderate excess of which does no harm.

135. Mené takes a boiling neutral solution of chloride of zinc, to which he adds a solution of a salt of nickel; sheet or granulated zinc is immersed in this solution, in contact with which must be the articles to be coated. The solution must be kept neutral.

136. Stolba deposits nickel or cobalt by forming a bath consisting of a solution of either metal, to which is added a dilute solution of chloride of zinc. A piece of metallic zinc is put in contact with the articles to be coated. A little hydrochloric acid is also added.

137. According to Jacobi and others, it is not necessary (as Mr. Adams says) to have solutions of nickel free from salts of potassium and other alkaline salts, as *a solution may* be made with the double sulphates of *nickel and* potassium.

138. *In* working brassing solutions, Mr. Walenn

says that the evolution of hydrogen at the cathode may be entirely stopped by employing *very* strong solutions of brass. When, therefore, the solutions become exhausted, fresh concentrated solutions of copper and zinc should be added to the bath. Mr. Walenn believes that the evolution of hydrogen in brassing solutions is owing to the small quantity of metal in solution, for when a larger amount of metal is employed, the evolution of this gas stops. He also prefers working these solutions hot.

139. Articles composed of iron may receive a stout and durable coating of copper or zinc by first coating them well in an alkaline bath (see p. 35) and then giving them a final coating in a so-called acid-bath, that is, a solution of either sulphate of zinc or sulphate of copper. These solutions, however, should be carefully neutralised by carbonate of soda or ammonia before using them for this purpose.

140. Plaster busts may be reproduced in electrotype by first coating the plaster with wax and then applying plumbago in the usual way. Upon this, copper is deposited by the battery of sufficient thickness to bear handling. The plaster is then to be broken away from the electrotype (which now forms the mould), and this is to be slightly rubbed over with oil. The mould is then to be placed in the bath until a sufficiently stout impression is obtained, when the copper mould may be broken away, and the electrotype bust, after being well freed from grease, may be bronzed by any of the processes described, or polished bright if desired.

141. Stereotyping, as it is termed, consists in taking an *impression of* the type in plaster-of-Paris or other material, *coating as* usual with plumbago or other conducto

and then depositing a thin coating of copper, which is afterwards strengthened by running in solder or lead.

142. Embossed cards, or paper (envelope crests, for instance), may readily be copied in electrotype by first saturating the paper slightly with wax. Plumbago is then to be brushed over in the usual way, when a deposit of copper will readily take place, and a perfectly sharp impression obtained.

143. Leaves, flowers, &c., may be copied by first dipping them in a solution of phosphorus in bisulphide of carbon, and then into a solution of nitrate of silver. The silver becomes reduced to the metallic state, which renders the object an excellent conductor.

144. Batteries which have a copper cylinder for the negative element, may have their *quantity* augmented by placing fragments of broken electrotypes at the bottom of each battery cell in close contact with the cylinder. The author has employed old rifle-caps for this purpose, placing several hundreds in each cell, by which means the quantity of the current was increased up to a certain point in proportion to the extra surface of copper thus presented.

145. Lace, net, and other similar fabrics may be coated with copper, by first dipping in melted wax. The superfluous wax must be removed by placing the net between two layers of blotting paper, and then passing a heated iron over the surface. Plumbago or bronze powder is then to be applied, and the article will be ready for the coppering bath.

146. Glass vessels may be covered with copper by *varnishing* or coating them with wax in the first place, *and then* applying plumbago, after which they are *ready for the* coppering bath.

147. It is a good plan to give a coating of varnish (shellac dissolved in spirit of wine, for instance) to the outer edges of electrotype moulds, to prevent the deposit of copper taking place upon those parts, but the varnish must not be too thin, nor too freely used, otherwise some of it may find its way upon the surface of the mould and thus render the impression imperfect. Grease of any kind, carefully applied, will answer the same purpose.

148. Silver bronze, as a conducting medium for electrotype moulds, may be very easily prepared as follows:—To a solution of nitrate of silver add sufficient solution of common salt to throw down all the silver in the form of chloride. Wash the precipitate several times, finally pouring off nearly all the water; now put in a piece of pure sheet zinc and add a few drops of sulphuric acid. Apply moderate heat, and in a few hours the chloride will be converted into a delicate bronze of pure silver, which should be washed several times with hot water, and finally dried on filtering paper. This silver bronze should be kept in a bottle well corked, as it would lose much of its conducting power if allowed to be exposed in a vitiated atmosphere.

149. Gold paint has sometimes been used to give a conducting surface to articles of a delicate nature.

150. Sealing-wax impressions do not readily receive a coating of plumbago; it is a good plan, therefore, to apply with a soft brush a little spirit of wine to the impression before plumbagoing; but this must be done with care, as the spirit, if too freely used, will dissolve the sealing-wax, and thereby spoil the impression. The object of employing the spirit of wine is merely to impart a *very slight* roughness.

151. Hooks and eyes, and other small articles which require to be silvered or gilt in large quantities, may be conveniently placed in an earthenware colander, the perforations of which should be tolerably large in order to admit the free exit of liquids. Hooks and eyes which are made of brass should be first dipped into a solution of caustic soda or potash to remove grease, and then be well rinsed. They must then be dipped for an instant in "dipping acid," and again rinsed several times. The perforated vessel, containing the hooks, &c., should then be placed in the bath, and the negative electrode put in contact with the hooks, and by employing this electrode as a *stirrer*, while deposition is going on, the articles will become uniformly coated all over; otherwise, were they not to be moved about, those parts which were in contact would not receive the deposit. Iron hooks and eyes should be first coated with brass or copper before being plated.

152. A solution of platinum, from which this metal may be readily deposited, is formed by adding a solution of chloride of ammonium (sal-ammoniac) to a solution of chloride of platinum. This mixture should be boiled for a short time, and then set aside to cool. Before using the solution, liquid ammonia is to be added gradually, until it is neutral to test-paper. The platinum solution will require strengthening with a concentrated solution of the double salts each time after it has been used.

153. Another process for platinising consists in taking a solution of the chloride of platinum as nearly neutral as possible, to which is to be added a strong solution of caustic potash until all the platinum is *thrown down*. The precipitate is to be well washed

with equal parts of alcohol and water, and finally with alcohol alone. The precipitate is then to be dissolved in hot distilled or rain water, and is ready for use. The solution is to be used while hot, the articles to be coated being dipped into it. After a few moments' immersion the article will at first appear somewhat dull, but soon assume a more brilliant appearance when the operation is complete. After the necessary deposit is obtained, the articles should be rinsed in boiling water and then dried in very clean box sawdust.

154. Lead may be successfully deposited from the following solution:—Dissolve about 3 ounces of litharge in a solution of caustic potash, and make into 1 gallon of solution. A leaden anode is to be employed, and the strength of the solution may be kept up by adding fresh litharge from time to time if required. Articles well coated with lead will resist the action of many acids, alkalies, &c.

155. For depositing palladium from its solution, the double neutral chloride of palladium and potassium have been recommended. Equal proportions of the salts should be employed, and the deposit allowed to take place after the manner of platinum.

156. Professor Jacobi introduced a very simple form of brassing solution, and one which, in the hands of an experienced operator, would give very good results. Having prepared a concentrated solution of cyanide of potassium, a copper anode is to be connected with two or three pairs of Smee's batteries, or one large Bunsen, and a sheet of zinc attached to the negative pole of the battery. These two plates are to be immersed in the cyanide solution, and galvanic action kept up until the solution has acquired the requisite

amount of copper. This becomes manifest by the zinc plate eventually becoming coated with this metal. The copper anode is now to be withdrawn, and a zinc anode substituted, the action of the battery being continued until the copper coating on the sheet zinc acquires the characteristic colour of brass, when the operation is complete, and the solution ready for use. The addition of cyanide from time to time will be necessary; and, doubtless, the addition of liquid ammonia, for reasons before given, would aid in keeping the zinc salt in solution. The above solution must be worked with a brass anode and vigorous battery power; for small articles a single Bunsen's battery will be sufficient, but for larger articles two or more cells would be required.

157. It has been stated that by adding small quantities of caustic soda or potassa to a solution of sulphate of copper for electrotyping purposes, the speed of the operation is greatly enhanced. The potassa or soda should be added to the solution of sulphate until the precipitate formed ceases to become re-dissolved by the solution.

158. By employing *very* weak solutions of copper or zinc from their sulphates, and rendering them neutral by means of a small quantity of carbonate of soda or potassa, a very tolerable coating of either metal may be imparted to iron or steel; but it is always preferable, in the first instance, to give a slight coating in an alkaline bath, and then to finish in the above solutions.

159. Since the deposition of iron upon copper surfaces, such as engraved plates, and the coating of type with iron, are now things to be desired, the experimental reader will do well to turn his attention in this direc

tion, as, doubtless, much will be required in this branch of electro-metallurgy in time to come, and the inventor's labours, if successful, it is to be hoped may meet with the reward which will be their just due.

160. Gilt articles of an inferior colour may be improved by coating them with a substance known as "gilders' wax." This article may be readily made by adding red ochre, alum, and verdigris, to beeswax in a melted state. The compound is to be applied to the gilt work by heating the article and then passing the wax over it, by which means sufficient will attach itself to answer the purpose. The article is then to be placed on red-hot charcoal until all the wax is burnt off. It is then to be placed in very dilute sulphuric acid, and then scratch-brushed. All articles must be well gilt before this process is applied.

161. The proto-nitrate of mercury in solution is useful in cases where the deposited metal has a disposition to separate, or strip, from the metal coated. This salt may be made by putting a few ounces of mercury into a Florence flask, and then adding diluted nitric acid—say, 1 part acid to 2 parts water, and applying gentle heat; care must be taken not to have an excess of acid. When the red fumes at first formed disappear, the solution should be set aside, when the proto-nitrate will crystallize. The supernatant liquor should then be poured off, and the crystals gently dried at a moderate heat. The crystals may then be dissolved in water, and the solution applied by dipping the article for an instant, until it has become thoroughly coated with mercury. It is important to avoid contact *with the solution* of mercury, and to rinse the fingers *at once if* they have accidentally become moistene

with it, and this for two reasons: first, the mercurial salt is injurious, and second, if it is allowed to come in contact with any gilt surface it will impart a coating of mercury to the part affected.

162. There is always a brisk effervescence in the brassing bath when deposition is taking place, owing to the intensity of the current required for this purpose; and unless this evidence of activity shows itself, the probability is that brass of a good colour will not be deposited. After the first thin coating is effected it is a good plan to remove the article from the bath, and if any defects present themselves, from want of proper cleaning or otherwise, let the article be well brushed with sand as before, and after rinsing, placed in the bath until sufficiently coated. Articles which have received a stout coating of brass may be "dipped" in the ordinary dipping acid (a mixture of sulphuric acid, nitric acid, and water, with occasionally a little nitrate of potash), which is to be procured ready-made at the drysalter's. Electro-brass articles thus dipped may then be lacquered in the ordinary way, that is by gently warming the article, and then brushing it over with a thin coating of gold or brown lacquer, according to taste. In brassing fender and stove work, which unfortunately is generally required to be done at a very moderate price, the object is to make the article look as well as possible with the smallest amount of metal. When we consider that fenders are sometimes electro-bronzed for two or three shillings each, it is not possible, with the labour required to make them look well, to give more than a mere film of deposit. This may *generally be* done in half an hour, or even in less time, *if the current is* vigorous and the solution in good order.

Even with this trifling deposit, however, such articles can be made to look exceedingly well by the after processes of bronzing and lacquering, when skilfully and tastefully accomplished.

163. Another preparation for colouring gilt or gold articles consists in mixing together nitrate of potash 5 parts, alum 2 parts, sulphate of iron 1 part, and sulphate of zinc 1 part. The ingredients are to be well mixed, and then water added to form a paste. The article to be coloured is to be dipped in the mass, then gently shaken to remove superfluous mixture, and placed upon a sheet of iron or copper, and heated until dry; the heat is then to be increased for two or three minutes, and the article is then to be plunged into cold water, and treated as usual to finish.

164. The substance known as "crocus," and which is so exceedingly useful as a polishing medium for steel, &c., may be very generally obtained in the cinders produced from coal containing iron. It will be easily recognised by its rusty colour, and should be collected and reduced to a powder for future use. Steel burnishers may be brought to a high state of polish with this substance by rubbing them upon a buff made of soldiers' belt or hard wood. After this operation, the burnisher should be rubbed on a second buff charged with jewellers' rouge.

165. French bronze may be prepared by reducing to a powder, hematite 5 parts, and plumbago 8 parts, and mixing them into a paste with spirit of wine. Apply the composition with a soft brush to the article to be bronzed, and set it aside for some hours. By polishing *with a tolerably* hard brush, the article will assume *the beautiful* appearance of real bronze. The desired

tint may be regulated by the proportions of the ingredients.

166. A very good imitation of the antique bronze green may be made by mixing strong vinegar half a pint, chloride of ammonium (sal-ammoniac) a quarter of an ounce, liquid ammonia half an ounce, common salt a quarter of an ounce. Brush this composition over the copper surface, repeating the operation each time after it has become dry.

167. Gold, and other solutions which are worked hot, should always have fresh water added to them after they have been in use some time, otherwise they will be apt to give ununiform results. When a gold solution, for instance, has been heated, say over a lamp, for an hour or so, the solution will have become considerably diminished *by evaporation*, and unless this loss be made up by adding water, the solution will be stronger than it was at starting, and consequently the results will be liable to vary. It is a good plan, therefore, to keep the depth of the solution gauged, so that when there is an appreciable diminution of the bath, the deficiency may be re-supplied. The small amount of solution removed by each article may, of course, be allowed for, but evaporation is the great source of diminution in the original quantity of the bath.

168. A very beautiful bronze colour may be imparted to copper articles, such as medals, for instance, by boiling them in a solution composed of verdigris 5 ounces, muriate of ammonia 5 ounces, strong vinegar half an ounce. Mix the verdigris and sal-ammoniac by *pulverising* in a mortar, and then add a sufficient *quantity of* the vinegar to form a paste. Now place *this in a copper* vessel with a pint of water, and boil it

about half an hour. When cold, stand the mixture aside until the sediment has subsided, when the clear liquor may be poured off, and bottled until required. The articles to be bronzed should be boiled in this liquor for ten minutes or longer, taking care that they do not come in contact during the operation.

169. Whenever there is evolution of gas at the negative pole during the operations of gilding or plating, it is a sure sign either that the battery power is too strong, the surface of anode in solution excessive, or there is too great an excess of cyanide in solution. Under either of these conditions the deposit will be faulty, and liable to strip. There should be no effervescence whatever at the negative electrode if the operation is proceeding satisfactorily.

170. A very pleasing effect may be produced upon an electrotype medallion thus:—Having well cleaned the electrotype by any of the processes given, apply varnish, with a soft brush, to the base or flat surface, carefully avoiding the figure; when the varnish has become hard, attach a wire to the electrotype, and place it in the gold or silver bath for a short time until sufficiently coated. Now remove the varnish and apply the solution of chloride of platinum or other bronzing material to the copper surface, and thus the figure will stand out in relief, either in gold or silver as the case may be. By employing the solution mentioned at page 44, the figure will appear dead white. A very slight coating of thin chloroform varnish will protect the silvered surface from oxidation.

171. When two surfaces of a medal have been copied, and it is desired to unite them so as to resemble the original, this may be readily done by cutting a

strip of copper from a thin sheet, forming this into a ring of the size of the medal, and carefully soldering it to its edge. A good plan is to tin the inner surface of the copper ring, as before recommended under the head of soldering, and by a moderate heat the ring can be made to attach itself to the edge of the medal. A smooth file and emery cloth, properly applied, will soon render the operation complete, and by this means a perfect copy of the original medal will be obtained.

172. Acetic acid, or strong vinegar, verdigris, and chloride of ammonium, in varied proportions, will give rich bronze tints to copper by boiling the article in a solution of the ingredients for a few minutes, the tint being regulated by the proportion of chloride of ammonium in the composition. Acetate of copper added to the mixture will also vary the tone. The articles, when removed from the solution, should be well rinsed in hot water.

173. It is very important, when gilding the insides of chased and embossed work, to have all the interstices perfectly clean. A little boiling solution of either caustic soda, or potash, will accomplish this readily, but if a brush is applied to the purpose it must be well rinsed after each operation, as the caustic alkali readily dissolves the bristles of which the brush is composed. After applying the alkaline solution, the article should be either scratch-brushed or well scoured with a hard brush, silver sand, and soap and water—the former being preferable.

174. The colour known as "ormolu" may be given *to gilt articles* by applying a mixture of alum, hematite, *salt, and strong* vinegar. The articles are dipped in *this mixture,* and then subjected to heat until the

composition becomes blackened, when they are to be placed in cold water, and afterwards brushed with vinegar until quite free from the colouring medium.

175. Any small article may be either slightly gilt or silvered by simply immersing it in a solution of gold or silver, as the case may be, in contact with a piece of clean zinc, which promotes electrical action, and forms a temporary battery. The coating thus given, though not durable, is generally very adherent, especially if the deposition takes place slowly.

176. To obtain a good reguline deposit of either gold, silver, or copper, from alkaline solutions, it is absolutely necessary that the operation should begin by slow degrees. Excess of battery power in proportion to the size of the article to be coated will give a deposit which will not adhere to the subjacent metal. Again, though the current may be moderate, if the surface of anode in solution be excessive, deposition will take place too rapidly, and the deposit will not adhere. These facts should be borne in mind by the beginner, otherwise his results will disappoint him, and nothing is so disheartening to the student as failure. Although the practical operator knows well how to regulate these conditions, those who have had less experience are very apt to fall into the errors we have indicated if not duly cautioned.

177. Cyanide should never be added to a gold or silver bath until it has been fully proved that tardiness of action is *not* due to the battery. It has been a common error with some electro-platers to add cyanide from time to time when the deposit has taken place *slowly;* whereas, in most instances, a diminution in the power of the current has been the cause of inaction

A large excess of cyanide is fatal to the proper working of the bath; therefore, before adding this substance, the battery and its connections should be well examined.

178. When solution of salt is employed to excite the zinc in a battery, it will be necessary to remove the zinc occasionally and clean it well with a brush and silver sand. A little hydrochloric acid will assist the operation. Amalgamated plates or bars of zinc excited by dilute sulphuric acid will not require this attention.

179. It has been proposed to employ a mixture of powdered zinc and plumbago to form a conducting medium for gutta-percha, wax, &c., in electrotyping. The powdered zinc may be made by melting zinc in a crucible or ladle, and when the metal is very hot, fragments of sheet iron are to be thrown in and the heat kept up for a short time longer. Zinc in this state may easily be reduced to powder, when it may be intimately mixed with plumbago and used in the ordinary way.

180. The fumes of hydrochloric acid or of chloride of lime will produce a very good green bronze upon electrotypes, giving them the appearance of ancient bronze. Another very good way to produce this effect is to envelope the object, if it be large, in an atmosphere of chlorine. This may be done by putting a small quantity of manganese in a Florence flask, and pouring upon it a little hydrochloric acid or sulphuric acid and salt. The gas which escapes may readily be conducted by a bent tube, inserted in a perforated cork, to the vessel in which the object is placed. The article should be exposed to the fumes for a short time, and

then placed in the open air, the process to be repeated until the desired effect is produced.

181. Electro-soldering may be effected by causing a deposit of copper to take place upon the two surfaces to be united. Thus a ring of copper may be formed by turning up a stout piece of copper wire to the required shape and size, bringing the ends tolerably close together. Varnish or melted wax should then be applied to all parts of the ring excepting the extreme points that are to be joined: A part of the ring, however, should be left free from varnish, to which the conducting wire of the battery is to be attached. The ring is then to be placed in the coppering-bath, and in a short time the deposit will completely and effectually unite the two ends, forming a perfect ring. Silver articles may be electro-soldered in the same way by employing a neutral solution of nitrate of silver for a bath.

182. When a soft metal is deposited upon a hard metal, or the latter upon a metal softer than itself, the exterior metal should be polished and not burnished, and for this reason:—If silver is deposited upon lead, for instance, the great pressure which burnishing requires to produce the necessary polish would cause the softer metal to expand, and consequently a separation of the two metals would result. On the other hand, silver being softer than steel, if the burnisher is applied to silver-coated steel, the exterior metal will expand and separate from the subjacent metal.

183. When articles have been boiled in caustic alkali or "ley," to remove grease, they may be dipped in very *dilute nitric acid* to remove the oxide which has formed *upon the surface*; but if they are well brushed with

moistened powdered pumice or Bath brick they may be very effectually cleansed without recourse to the acid solution.

184. When a bath has been at work some time, the uniformity of its condition becomes disturbed; it is better, therefore, to move the articles in solution occasionally by dipping them up and down several times, taking care, however, not to disturb any sediment which may lie at the bottom of the vessel. The rods to which the anodes are attached may also be gently moved occasionally with advantage.

185. When the current employed is too intense, the deposited metal will become excessively hard—so much so that it will be difficult to obtain a good polish by means of the burnishing-tools without considerable labour. In the early days of electro-plating many of the burnishers who entered the author's employ were struck with the difference between the work submitted to them and that which they had been accustomed to in other establishments. It appeared from the statements made at that time that in some electro-plating works the deposit was so exceedingly hard and "scratchy," that the women whose task it was to burnish it frequently worked in acute agony. When a good quantity is employed, of moderate intensity, the deposit is not only better in character, but it is more easily and successfully burnished.

186. When the gold bath is worked at a lower temperature than 130° F., the colour of the deposit is apt to be rather pale in colour. The richest colour is *undoubtedly* obtained when the solution is rather above *than below* this temperature. If the solution, however, *has been long* in use, and has acquired a certain amount

of organic matter, and, perhaps, a little copper (from the positive electrode occasionally dipping into the solution when the anode is nearly exhausted), a fair-coloured deposit may be obtained below 130° F.

187. Whenever a gold solution begins to give indifferent results, more especially as to colour, the best and simplest remedy is to evaporate it to dryness. This operation always repays for the little trouble and time expended upon it, and the dried mass, when redissolved in boiling distilled water, with a little additional cyanide added, will result in a gold bath which it will be a real pleasure to work with.

188. Articles of tin, lead, pewter, iron, or steel should receive a coating of copper in the alkaline bath before being either plated, gilt, or nickelled. This does not add much to the trouble, but it certainly favours the adhesion of the superior metals.

189. When an article is too large for the bath, and it is necessary to do it piecemeal, the greatest care will be necessary to obtain a good deposit at the junction between the first coating and the underlying metal. If the first layer or deposit has not been tolerably thick, when the second portion of the article has been immersed in the solution some time, it will be found that at the line near the surface of the solution the deposited metal has become dissolved, or as it were cut off. To prevent this, it will be necessary to move the article frequently while in solution until the union between the first and second coating becomes as perfect as possible. Even with the greatest care the deposited metal is very liable to strip at the junction of the two coatings.

190. *Metallo-chromes*, as they are termed, are beautiful colorations obtained by means of the battery upo

plates of polished steel. The method of procedure is the following:—Make a saturated solution of acetate of lead (sugar of lead), and filter until perfectly clear. Next lay a plate of highly-polished steel in a shallow vessel, and pour the above solution upon it. The wire proceeding from the copper element of a compound battery of five or six pairs is then to be put in contact with this steel plate. If, now, the wire issuing from the zinc of the battery be held a short distance above the centre of the steel plate a very remarkable and beautiful effect will be produced, in the form of a series of coloured rings of great brilliancy. After a few moments these rings of varied colour will increase until the plate is covered. If a piece of copper, cut in the form of a star, a diamond, or any other shape, is attached to the end of the wire, the colorations will assume upon the steel plate a corresponding shape; and if a piece of card is intercepted between the wire and the steel plate, the colorations will take place beyond the point screened by the card. As it is rather difficult to hold, for any length of time, the copper wire with sufficient steadiness to obtain good results, the wire may be passed through a perforated card, and this allowed to rest across the vessel in which the operation is performed. The colours produced by this beautiful process resemble those obtained by the prism, but as they do not adhere closely to the metal plate, the latter should be carefully washed in boiling distilled water, and when dry the plate may be varnished with any good white spirit varnish. The colouration of metals *by electricity* was first discovered by Dr. Priestley, but *it was Nobili* who first obtained coloured deposits upon *metallic surfaces* as described above.

191. Woodcuts may be coated with plumbago and then copied in electrotype. The reverse thus obtained may in its turn be slightly oiled, and then placed in the bath to receive a deposit which will be as sharp as the original, and the same copper mould may be employed again and again for the same purpose.

192. Intaglios, or moulds, may be obtained from medals, coins, &c., by pressing them upon tin-foil, which will readily receive the required deposit of copper. To give additional strength to the foil, melted wax, sealing wax, or stearine may be employed.

193. Sheet or bar iron may be employed in place of zinc as a positive element for a constant battery, but the acid solution employed to excite it should be weak

194. For the convenience of jewellers, watchmakers, and amateurs living at a distance from large towns, the author has designed an electro-metallurgical cabinet containing everything that will be necessary to enable its possessor to carry on the operations of electro-plating and gilding practically; and as the arrangement of the cabinet has been made with considerable care, so that it should be serviceable not only as a means of studying these beautiful arts, but also as a source of profit to those who desire to use it for such purposes, it is to be hoped that it will meet the wishes of those for whom it was projected. The manufacture of this cabinet has been entrusted to Messrs. How & Co., of 73, Farringdon Street, London, the successors to the late eminent firm of George Knight and Sons.

195. Nickel may be deposited upon copper for experimental purposes from a solution of its chloride, by *placing a piece* of clean zinc in contact with the copper *while in solution.* The solution should be warm.

balt, iron, and other metals may also be deposited in a similar way, the strip of zinc performing the office of a battery.

196. The "single cell" arrangement will be found very useful for obtaining deposits of the various metals from their respective solutions, when the object of the manipulator is merely to give a slight coating as an illustrative experiment; and in this case a very small porous cell, supplied with a small bar of zinc with copper wire attached, will be quite sufficient to coat small articles with any given metal. When the same apparatus is employed to deposit several different metals from their solutions, the porous cell, &c., should be thoroughly well cleaned after each solution has been used. The student may obtain a very interesting collection of electro-deposited metals by coating small pieces of sheet copper with the various metals, and arranging them in a cabinet, duly labelled. The strip of zinc suggested in the foregoing paragraph, and a very small quantity of solution, will be all that is required to coat a small piece of copper with almost any metal. A series of small coins, copied in electrotype and then each coated with a different metal, would form a very interesting collection.

197. It is very important that the divisions in the commutator of the dynamo-electric machine should be kept clear, that is, free from the small particles of copper produced by friction of the brushes, &c. This is easily effected by passing a piece of card through each groove, at least once a day, when the machine is in use.

198. All things being equal, the characteristic tint of brass should present itself upon the surface of the

work almost immediately after immersion in the bath. If this be the case, the action may be allowed to continue for a few minutes, or until a perfect film is obtained, when the energy of the operation may be somewhat diminished by raising the anode out of the bath a few inches, so as to expose a smaller surface (in solution) to the article to be plated.

199. When it is necessary to deposit a stout coating of silver upon the work, it is better to have the solution rich in metal, from two to four ounces of silver being sometimes employed to each gallon of solution. When the dynamo-electric machine, instead of ordinary battery power is adopted for depositing silver in large quantities, the solution should have at least two ounces of silver per gallon.

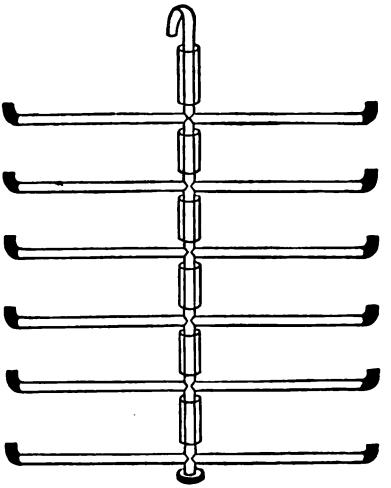
200. The colour or tone required for cast-iron work which has to be "bronzed" after electro-brassing, depends much upon taste. In some cases the high lights are required to exhibit a yellow or brass-like appearance; in other cases a warmer tone, approximating a copper tint is preferred. To meet both these requirements, it is only necessary in the latter instance to employ an excess of copper in the bath—for example, equal parts of zinc and copper for a warm tone, instead of the usual two parts of zinc to one of copper to form yellow brass. Much of this detail will depend upon the judgment of the operator, who may vary the character of his deposit by modifying the proportions of the two metals (zinc and copper) at will. But it must be borne in mind that in employing the bronzing powders (see page 38, &c.,) it will be necessary to suit the colour of the powder to the tone of the deposit. For example, a warm chocolate tone would not be appro-

priate for a yellow brass deposit, nor would a green bronze tint suit the red copper coloured deposit. There are so many examples of bronzes to be seen in our museums and curiosity shops, that the student will do well to examine some of these before devoting himself to the art of producing artificial bronzes.

201. A convenient support for spoons and forks, and other articles, consists of a copper wire bent to the form represented in the woodcut. Before bending the hook at top, a piece of glass tubing is slipped over the wire—the object of which is to prevent the deposit of silver or other metal upon this part of the wire. Vulcanised india-rubber tubing will answer the same purpose, and is less liable to fracture.

202. The subjoined woodcut represents a useful contrivance for suspending certain small articles, such as umbrella-mounts, ferrules, &c., in solution. It may be very readily constructed thus:—Take copper-wire about $\frac{1}{8}$th of an inch in thickness. Cut one length for the upright support, about 18 or 20 inches. Next cut six or eight shorter lengths, for the horizontal wires: each of these shorter wires should be bent at the ends, as in the woodcut. Now fasten, by means of a wire or by soldering, the lower cross-bar or wire to one end of the perpendicular wire, and slip over it a piece of glass tubing or vulcanised india-rubber tube, about three inches in length. The next cross-bar is then to be attached as before, and a second piece of tubing placed above it; the other horizontal wires being attached, with alternations of tubing between each, until the *required* number have been placed in position. When *the upper* or last piece of tube has been slipped over

the vertical wire, its upper end is to be bent into the form of a hook. The ends of each of the cross-wires are next to be covered with a short piece of india-rubber tubing, to protect them from receiving the deposited metal. When properly constructed, this contrivance will support from one to two gross of um-



brella mounts. The advantage of protecting those parts of the wire which are not connected with the articles in solution will be at once recognised.

203. The Americans employ a plumbago-brushing machine in electrotyping, by means of which they are enabled to give the required conducting surface to wax with perfect uniformity. It is well known that the art of electrotyping is carried on more successfully in the United States than in any other country, and this is *doubtless owing* to the employment of dynamo-elec-

tricity and the machine for coating the moulds with plumbago. It is said that "pin-holes" are comparatively rare in establishments where this latter machine is employed. There is, we believe, but one of these plumbagoing machines in this country—which is in the possession of a London firm.

204. It is very important that articles which have been nickel-plated should be kept free from damp, otherwise the polished surface soon becomes dull. The simple plan of wiping the articles each day with a dry cloth will keep them from being affected by moisture. If this be neglected, the handsomest specimens of work soon become unsightly. Mullers, sausage-warmers, and other articles which are constantly kept hot from day to day, never assume the dullness peculiar to nickel which has been suffered to remain coated with moisture. A nickel-plated and polished surface appears to have a great affinity for moisture.

205. Certain vegetable substances have a peculiar effect upon nickel-plated work. Beer, mustard, cabbage-water, tea, and many other vegetable infusions produce a dark stain, which is not easily removed. All nickeled articles, therefore, which have come in contact with such substances should be at once washed in hot water, dried, and put aside in a dry place.

206. Nickel-platers should be very careful not to allow the lime used in finishing the work to be exposed to the air, otherwise it will soon become unfit for use; and since this important article (which is generally obtained from Sheffield) is not very readily obtainable during the winter months, when it is often most required, it is a good plan to keep a stock of fresh lime *hermetically* sealed until required. For this purpose,

olive-jars will be found very serviceable, since they are not only capacious and cheap, but from their form they are very readily kept securely covered either by a large bung or by a piece of softened parchment or bladder. Thin sheet gutta-percha may also be used with advantage for this purpose. Each time that the jar has been opened it should be well and securely closed again, for if the air is allowed to come in contact with the lime it will render it useless for finishing nickel-plated work.

207. In working Daniell's batteries, it will sometimes be found that a deposit of copper will take place upon the zinc element. This is due to *endosmic action*—that is, the passing of the solution in the outer cell to the interior of the porous cell. By its superior gravity the solution of sulphate of copper is enabled to force its way, so to speak, through the pores of the latter, and as a matter of course the zinc readily reduces the copper to the metallic state. When this occurs the battery ceases to act. The zinc bar must be thoroughly freed from any copper deposit which attaches to it, and should be re-amalgamated. The porous cell must then be well washed with hot water, and examined. It is not unlikely that a crystallization of metallic copper will be found to have taken place at the bottom of the porous cell, in which case the cell must be discarded. *Exosmic action*, or the passing of the solution from the porous cell to the outer vessel, will sometimes cause a deposit of zinc upon the interior of the copper cylinder, and thus the battery will cease to perform its function. To prevent these annoying and irregular actions of the battery the solutions should be frequently renewed; and on no account should the zinc bar be *allowed to touch* the bottom of the porous cell.

208. Messrs. Prime and Sons, of Birmingham, have a most ingenious contrivance for keeping articles in motion while deposition is going on in the silver bath. By a simple arrangement, the suspending rods slowly advance and retire between the anodes, to the extent of a few inches, whereby a perfectly uniform coating of silver is obtained. The author was much struck with the extreme beauty and uniformity of deposit upon spoon and fork work, by means of the dynamo-electric machine, which he was enabled to witness through the courtesy of this distinguished and well-known firm.

209. When a small spot in some nickeled article has been "cut through," or rendered bare, in the process of finishing, it is sometimes the practice to apply the "doctor," as it is termed, whereby a slight coating may be deposited upon the spot, and thus the necessity of replating the whole article is avoided. This may be done as follows:—Take a strip of stout copper wire about 12 inches long and bend into the form of a hook at each end. Now attach a small piece of plate nickel, say about 1½ inch square, to one end of the wire, and cover it with several folds of rag or chamois leather. Connect the upper end or hook of the "doctor" to the anode, dip the rag end in the nickel solution, and apply to the spot to be coated: the article itself must be placed in contact with the negative pole to complete the circuit. By repeatedly dipping the rag in the nickel-bath and applying as before, sufficient metal may be deposited in a short time to enable the finisher to apply the "dolly," and thus render the offending spot as bright as the remainder of the article.

210. Adding common salt to nickel solutions has *long been* a favourite custom with the French nickel-

platers, and we know that this addition has been successfully adopted by several firms in London. The primary object in adding common salt to a nickel bath is to increase its conductivity, for it is well known that a nickel solution, pure and simple, is a very poor conductor of electricity as compared with solutions of most other metals. That common salt may be added with advantage to nickel solutions has been well tested and proved by M. Desmur, who, in a communication to the author in June, 1880, makes the following interesting statement:—

"*Augmentation of the Conductivity of Nickel Baths.*—The resistance of nickel baths as they are usually prepared, *i.e.* by dissolving double sulphate of nickel and ammonia in water, is very great. I would advise persons engaged in the trade to introduce into their baths ten per cent. of chloride of sodium (common salt). I have observed, by means of a rheostat, that the addition of this salt augments the conductivity by thirty per cent., and that the deposit is much whiter, and obtained under better conditions. The diminution of resistance is in proportion to the quantity of chloride of sodium added, for the conducting power of a solution of this salt increases with its degree of concentration up to the point of saturation. I mention this fact because it is not the case with all saline solutions. For example, saturated solutions of nitrate of copper or sulphate of zinc have the same conductive power as more diluted solutions, because the conductibility of these solutions increases as the degree of concentration reaches its maximum, and *diminishes as* the concentration increases."

M. Desmur also favoured the author with the follow

ing formula for coating small articles, which may be well worth the attention of practical platers :—

"For small articles which cannot be polished, and especially for thin struck articles, I would recommend the following bath :—

Double sulphate of nickel and ammonia .	7 kilogrammes.
Bicarbonate of soda	800 grammes.
Water	100 litres.

"The bicarbonate of soda must be added when the nickel solution is warm, in small quantities at a time, otherwise the effervescence which occurs may cause the solution to overflow. The bath is to be worked up to nearly boiling point. If after working for some time the deposit becomes of a darkish colour, add a small lump (about the size of a nut) of sulphide of sodium, which will remedy it.

"Of all the solutions of nickel which I have tried, this has, without doubt, given me the best results both as to quickness in working and whiteness of deposit, which is equal to that of silver. Nickel deposited from this solution can be burnished.

"If the nature of the articles to be nickeled will not allow them to be either polished or burnished, they may be rendered bright by first dipping them in nitric acid and afterwards passing them rapidly through a mixture composed of old nitric acid dip (already saturated with copper), sulphuric acid, greasy calcinated soot, and common salt."

We would recommend nickel-platers desirous of trying the addition of common salt to their baths, to *practise* upon one gallon of solution at first, adding the *salt in moderate* quantities at a time.

211. The following formula for a silver solution

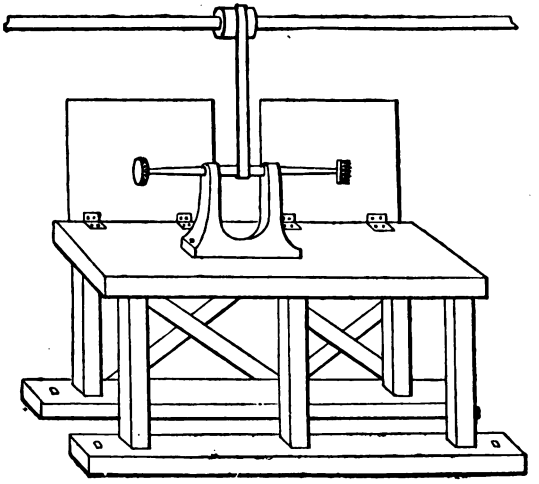
which will yield a thoroughly adhesive coating of silver upon German silver, copper, or brass, without the aid of the mercury dip, will be useful to those who, like the author, have a dislike to the employment of mercury in the preparation of work for plating. One ounce of fine silver dissolved and crystallized in the usual way. Dissolve the crystals in about three pints of distilled water, precipitate with a solution of *iodide of potassium*, made by dissolving about 1½ ounce of the iodide in half a pint of distilled water. Add this solution gradually to the nitrate solution, when a yellow precipitate of *iodide of silver* will be formed. Test the clear liquor repeatedly, so as to avoid adding an excess of the iodide, which would redissolve the precipitate. Wash the precipitate thoroughly by repeated applications of distilled water. To dissolve the iodide of silver pour into the vessel gradually and with constant stirring a solution of cyanide of potassium (say about 4 ounces to a pint of water). When the iodide is quite dissolved, add a slight excess of cyanide solution, and set the solution aside for twenty-four hours, when the clear liquid may be poured into the plating bath and the latter portion filtered, so as to free it from any sediment which may be present from impurities in the cyanide. Water is now to be added to make up one gallon of solution for each ounce of fine silver dissolved, and the solution should be set aside for several days before using it. To prepare the work for plating the method we have followed successfully is this: immerse the articles for a few minutes in a hot solution of caustic potash or soda, and then rinse in water. Scour each article well with a three, four, or five-rowed brush (according to its size and shape) and finely powdered

and sifted pumice, or still better, bath brick reduced to a powder and sifted. The latter will be found a very suitable material for this purpose, since it does not cut so severely as the pumice, while at the same time it produces a surface very favourable alike to the reception and adhesion of the silver deposit. When scouring the work the hands *must be clean*, that is, "chemically clean." A good plan at starting is to put a little dry pumice in the palm of one hand, and then rub the two hands together, which will prevent them from coming in *direct* contact with the work. The hands being thus prepared may handle the work more freely, without fear of conveying greasy matter to the articles. In scouring the articles, dip the brush in water, shake off the superfluity, then dip in the pumice, and brush briskly over the surface, taking care not to have the brush too wet, which wastes the pumice and prevents it from doing its work properly; the powder should be *damp*, but not drenched with water. Lastly, having brushed the article well all over, give it a final quick brushing over the entire surface, rinse it quickly in water and place it in the plating bath *immediately*. In the case of small articles, such as spoons and forks, the slinging wire should be attached as each article is cleaned, and these may be placed in a pail of clean water (entirely covered) for a few moments, until about a dozen or so are cleaned, when they are to be placed in the bath with as little delay as possible.

The above solution may be used as a substitute for "quicking," if preferred, by giving the articles, prepared as above, a preliminary coating in the iodide *bath*, and then transferring them promptly to any *other* ordinary silver bath. Silver solutions prepared

according to the above formula have been worked for a period of about thirty years with perfect satisfaction.

212. Nickel polishing and finishing are accomplished much in the same way as ordinary brass finishing. Since it is probable, however, that some readers may be unacquainted with this process, the following details may prove acceptable. The operation is conducted at a lathe similar to that represented in



Polishing Lathe.

the engraving, which consists mainly of a revolving spindle secured to a strong bench; in the centre of the spindle are a fast and loose pulley, which are connected by a belt to shafting set in motion by steam power. Each end of the spindle (which tapers to a point) is screwed, so that certain discs of wood covered with leather, called "bobs," may be connected or removed from time to time as required. The material

employed in nickel polishing is fresh lime obtained from the neighbourhood of Sheffield, and is well known in the trade as "Sheffield lime." The following extract from the author's "Mechanical Industries Explained" will show how nickel polishing is carried out practically:—

"The lime is selected from the kilns by persons who know the requirements of the trade, and is sent in casks or barrels to the London polishers, who preserve it from contact with the air by keeping it in olive jars or large tin chests carefully covered up. When required for use, a few lumps are removed from the jar; these are first scraped to remove coarse impurities from the surface, after which they are broken in small pieces, and these are afterwards pulverized in an iron mortar. The powder is next passed through a fine hair sieve or muslin, when it is ready for use. Only sufficient lime is thus treated for immediate working, as it loses its *cutting* properties by exposure to the air.

"In lime *finishing* the operation is conducted by a superior workman, and much of the beauty of the work depends upon the care and skill with which this is performed. The lime is applied, with a little oil, to the bobs; and being worked over and over again during the operation, it becomes impregnated with the particles of metal which it has removed from the work, and this increases its polishing power. It may be well to state here that it is not the polishing medium, whether it be lime, rouge, or other substance, which gives the brilliancy to a metal surface; it is *the metal which becomes removed from the surface* of the work *which* actually effects the object.

"*After* having gone over the work very carefully

and examined it, the finisher removes the lime-bob from the spindle and fixes a 'dolly' in its place. The dolly for this purpose is made of many layers of unbleached calico, cut into a circular form, and braced together by discs of leather or metal secured by rivets. A hole is made in the centre to admit the point of the spindle. Dry lime is used with the dolly, and the combined effects of this and the frayed edges of the cloth produce an exceedingly fine surface upon the work."

213. *De-gilding* (as we may term it), or stripping gilt articles, may be done by attaching the article to the positive pole of a battery and immersing it in a solution composed of 1 lb. cyanide dissolved in about 1 gallon of water. *De-silvering* may be effected in the same way.

214. "Stopping off" is a process which is applied to certain parts of a silver or plated article when other ornamental parts or surfaces are to be gilt. Almost any good hard varnish would answer this purpose if cold cyanide solutions were used; but as gilding solutions are invariably worked hot, it is necessary to blend certain materials together which will resist to a considerable extent the action of cyanide. Good copal varnish mixed with jewellers' rouge may be used for this purpose, but the varnish must be thoroughly dry before placing the article in the bath. The following composition has also been recommended:—Yellow rosin, 10 parts; beeswax, 6 parts; red sealing-wax, 4 parts; jewellers' rouge, 3 parts. The ingredients must be well incorporated together by heat, with gentle stirring.

215. *Plating* baths for small operations—say up to

ten or twelve gallons—may consist of ordinary "stone-ware," long oval vessels being well suited to the purpose. Tanks for large operations may be composed of slate, put together with iron bolts, the joints being secured from leakage by means of india-rubber.

216. A mercury dip, for "quicking," as it is termed, may be readily made thus :—Dissolve one ounce of quicksilver in nitric acid diluted with about three parts of distilled water, taking care to have an excess of mercury. Now add about one gallon of distilled water acidulated with about two ounces of sulphuric acid. Another and better solution for this purpose, is made from the cyanide of mercury. Dissolve an ounce of mercury as before, and dilute the nitrate with about one quart of water. Add to this, gradually, a solution of cyanide of potassium, until no further precipitation occurs. Now pour off the clear liquor and filter the precipitate, which should be washed in the filter by adding fresh water when it has drained thoroughly. The precipitate is then to be placed in a glass or stone-ware vessel, and a strong solution of cyanide added to it until it is dissolved, a moderate excess of cyanide being used. Water is then to be added to make up one gallon.

In using the mercury dip, the articles should first be slung on copper wire and then plunged for a short time in a hot potash solution, then well rinsed and put into the "quicking bath." After a few moments the surface of the metal (copper, brass, or German silver) will assume the bright lustre of quicksilver. When, however, the solution is too strong, or after it has become exhausted by long use, the articles will come out of the bath of a dark, or nearly black colour.

When removed from the mercury bath, the articles are to be well rinsed and placed at once in the gilding or silvering bath, as the case may be. Since the object of "quicking" is to assist the adhesion of gold or silver to the underlying metal, the operation must be conducted with care, and with no more mercury than is sufficient to make the articles white and of a bright appearance like quicksilver.

217. In nickeling small articles, such as dental forceps, &c., by the dynamo-machine, they should not be kept in the bath longer than from an hour to an hour and a half; when battery power is used about twice this time will be necessary. Brass and copper articles may, as a rule, be allowed to remain in the bath about twice the length of time required for steel articles.

Large brass and copper articles, as mullers, for example, must be literally surrounded by anodes, otherwise they will not receive a uniform coating of nickel. The best plan is to place rows of anodes at a short distance from the work, on either side, and then to place two short brass rods across the positive conducting rods, at the same time insulating them from the negative rod by pieces of wood, or small pieces of vulcanised india-rubber tubing slipped over the short rods.

218. To make up a nickel bath, dissolve the crystals of double sulphate of nickel and ammonia in hot water. This may best be done by pouring upon the crystals, which may be placed in a clean and new bucket, a quantity of boiling water. Now stir well with a piece of wood. In a few minutes the water will have become *saturated,* when the solution should be filtered into the

plating tank. To do this, it is a good plan to place a strainer (made by stretching a piece of stout calico over a wooden frame), across two of the suspending rods, and filter the solution direct into the bath. Fresh water should then be poured on to the undissolved crystals until the entire quantity is dissolved, when water must be added to make up the full quantity of bath. For a fifty-gallon bath about 40 pounds of pure nickel salts should be used, and when the solution has attained the temperature of 60° Fahr. the hydrometer should be floated in the solution, when, if it marks 1,050 (water being 1,000), it is the proper strength for working. If below this, more crystals of the double salts must be dissolved in a portion of the nickel solution and this well stirred in. Although nickel salts vary in the proportion of metal contained in them, if purchased at a respectable house the proportion given will be found to make up a very good bath. When the solution is complete, a strip of blue litmus paper should be dipped into it, when, if it turns red, a few ounces of liquid ammonia must be added, with brisk stirring, and the solution tested again. The solution should be as nearly neutral as possible, but a trifling excess of ammonia will do no harm. In working nickel solutions, it is sometimes usual to stir them well each evening; some platers are satisfied by doing this once a week.

219. In nickeling small work, as screws, for example, they should not be put into the bath alone, otherwise they will "burn," as it is termed, and thus give the plater some trouble. It is better to suspend such *articles* between work of a larger size. Sometimes *screws* have been placed in a gauze-wire tray for con

venience of plating them, but it is far better to sling these articles upon a thin wire, and the little trouble this involves is more than counterbalanced by the uniform character of deposit which they will receive in the bath.

220. Roseleur recommends the following formula for depositing platinum to any required degree of thickness :—

Metallic platinum	10 parts.
This is to be converted into chloride (see page 84).	
Distilled water	500 „
Dissolve and filter phosphate of ammonia (crystallized)	100 „
Distilled water	500 „

Add this, with constant stirring, to the platinum solution, when a copious precipitate will be formed. Now add, stirring well, a solution previously made, consisting of

Phosphate of soda . . .	500 parts.
Distilled water	1000 „

The above mixture is to be boiled until the smell of ammonia ceases to be apparent, and the solution, at first alkaline, reddens blue litmus paper. The solution is at first yellow, but afterwards becomes colourless, when, after filtering, it is ready for use. This solution must not be used for depositing upon zinc and lead, because they become platinised in it without the aid of the battery. It is recommended specially for coating copper and its alloys (as German silver, for example). The solution is worked hot, with vigorous battery; but since a platinum anode would not be *dissolved* by the solution, the occasional addition of

a strong solution of chloride of platinum will be necessary.

In working alkaline solutions of platinum, which do not dissolve the anode, it will be found more economical (as saving the cost of the platinum) to employ anodes of carbon, which will answer the purpose fully as well.

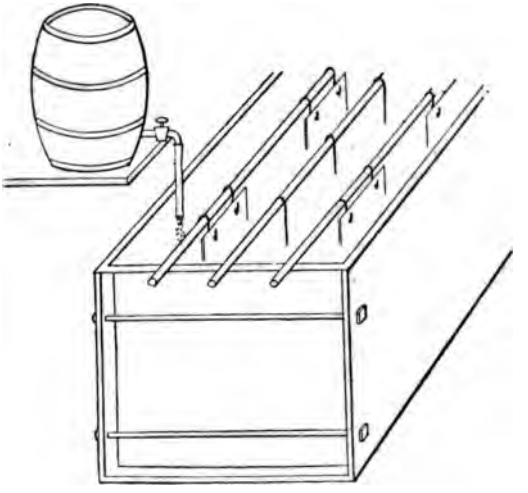
Boettger recommends a solution composed of a mixture of chloride of platinum and chloride of ammonium, with the addition of a few drops of a solution of ammonia. The solution, which is made very weak, is used at a boiling temperature.

For depositing platinum upon a practical scale the arrangement suggested for keeping up the strength of tinning baths (page 241) may prove useful. An ordinary glass funnel, with its aperture partially closed by a wooden peg, may be filled with concentrated platinum solution, which, dripping from the funnel into the platinum bath, will keep up the strength of the solution while the process of deposition is taking place. The funnel may be supported by a retort stand placed close to the depositing trough, the tube of the funnel being allowed to nearly touch the solution.

221. *Tinning Solutions.*—The electro-deposition of tin has during the past few years gradually assumed a position of some importance, and indeed it seems likely to become a valuable branch of the electro-depositor's art when the public have been brought to recognise electro-tinned articles with favour.

The fact that the solvents of tin salts act but sparingly upon anodes of metallic tin has always been a serious drawback in depositing this metal by the *battery* or electric-generator. This being the case it is *evident* that a tinning solution, after being worked for

ıe time, would become poorer in metal than when t made up. To overcome this it is necessary to to the bath frequently, when it has been much d, a concentrated solution of tin salt. We would gest the following method of keeping the bath in a form condition to those who are engaged in depo- ɔn of tin upon a large scale:—Arrange above the ositing tank a stone jar, as in the engraving, with a



Tinning Bath.

; to this attach a glass or vulcanised india-rubber e, reaching nearly to the surface of the solution. ; this jar be nearly filled with a concentrated solu- ı of the tin salt employed (made by dissolving the ; and its solvent in a portion of the main solution). ıen *the bath* is being worked, let the tap be turned *htly, so that* the concentrated solution may drip or

flow into the depositing bath. When the stone jar becomes empty, or nearly so, a fresh concentrated solution should be made with the liquor of the bath, and the proper proportions of the tin salt and its solvent (caustic soda, &c.). By this method several advantages would be gained. 1. By using the weakened bath each time to make the concentrated solution there would be but a trifling addition to the quantity of the bath, which would not be the case if its strength were renewed by putting additional quantities of strong solution. 2. By allowing a concentrated solution of this salt *continually* to drip or flow into the bath while deposition is taking place there will be no necessity to disturb the bath by stirring in a large quantity of strong solution. If the top of the tinning solution be occasionally stirred gently with a flat wooden spatula there is little doubt that a very fair degree of uniformity could be kept up without disturbing the lower portion of the solution and any sediment which may have accumulated at the bottom of the vat.

There are many kinds of tinning solutions now being worked upon a more or less extensive scale. Mr. Fearn, of Birmingham, patented several solutions, from which we select the following:—

A nearly neutral solution of chloride of tin is prepared, containing three ounces of metallic tin per gallon. Next dissolve in twenty gallons of water—

Cyanide	} 30 lbs.
Caustic potash	

and in sixty gallons of water dissolve

Pyrophosphate of soda . .	30 lbs.

Two hundred fluid ounces of the tin solution are to be

gradually poured into the potash solution, and well stirred in. A precipitate at first forms, which subsequently becomes redissolved. The cyanide solution is now to be added, and finally the solution of pyrophosphate of soda. The whole must be well stirred, and the solution then set aside to repose for a few hours.

Roseleur makes up a solution composed of—

Chloride of tin (fused) . . .	5 parts.
Pyrophosphate of soda or potash .	50 ,,
Water	5000 ,,

The chloride is to be dissolved in a portion of the water, and the pyrophosphate in the remainder. The chloride solution is then to be poured into the latter solution with brisk stirring until the mixture, at first cloudy, becomes bright and clear. In working this solution a large surface of tin anode is employed, and a powerful current of electricity. The addition of equal parts, by weight, of the tin salt and pyrophosphate must be added from time to time to keep up the strength of the bath.

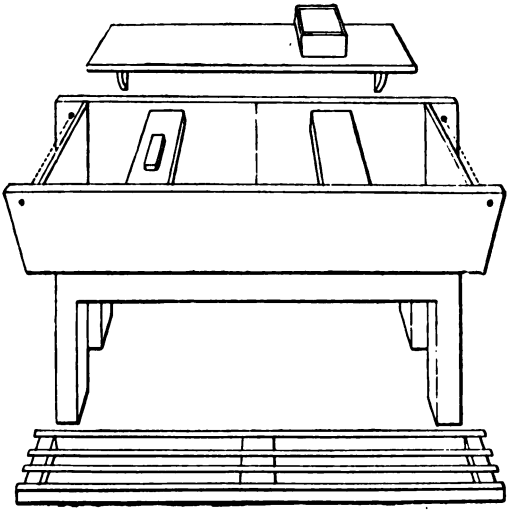
222. To those who desire to make up a brassing solution, we would recommend the following *direct* method as being more simple, and, we believe, more trustworthy than some other formulæ which are adopted. For each gallon of solution take, say, two ounces of sheet brass of the best quality, cut it into strips and place them in a porcelain capsule or stone jar. Now pour in about four ounces of commercial nitric acid, to which a little water may be added. Allow the chemical action to proceed in a cool place until the red fumes cease to be given off, when gentle heat may be applied. *When chemical* action has entirely ceased, decant the *solution, and* add a small quantity of acid to the un-

M 2

dissolved metal, taking care not to use an excess of acid. It is preferable to put aside the small quantity of undissolved brass than to have acid in excess. The solution of brass is next to be placed in a tolerably large vessel and diluted with about two quarts of cold water. Now dissolve half a pound of carbonate of potash ("salt of tartar") in about three half pints of water, and add this *gradually* to the solution with *gentle* stirring. Upon adding the carbonated alkali effervescence will take place, therefore its addition must be cautiously made, to allow the carbonic acid to escape, otherwise the mixture will overflow, carrying much of the precipitate with it. This precaution is specially necessary when the precipitation is near completion.

A light bluish-green precipitate is formed, which must be allowed to subside, when the supernatant liquor may be poured off and fresh water added repeatedly to wash the precipitate. Strong liquid ammonia (sp. gr. ·880°) is now to be poured on to the precipitate gradually, and with constant stirring, until it is redissolved, when a dark blue solution will result. To this must now be added strong solution of *good* cyanide of potassium until the blue colour entirely disappears, and beyond this about four to six ounces of free cyanide must be added. The solution must next be made up to one gallon by the addition of water. It may be worked either hot or cold, but if warm it may be reduced in strength by adding a little water. The anode should be of the same quality of brass as that used for making the solution; and indeed if the alloy be of first-*rate* quality and the solution carefully prepared, it should *yield results* fully equal to any that can be obtained *by the* ordinary methods of making such solutions.

223. A very convenient form of scouring tray for preparing work for nickel and other kinds of plating is shown in the wood-cut. The tray may be constructed from 1½-inch deal, planed smooth, and the various parts well braced together with iron bolts. The vessel must be made thoroughly water-tight, either by placing india-rubber in the joints or by some other suitable means. One or two shelves are fixed across the tray,



Scouring Tray.

inside, a little below the upper edge, upon which the work is scoured. A block of wood about 7 inches long and 2 inches square should be secured to one of the shelves for the convenience of scouring small articles. A shelf is placed above the tray for holding boxes of pumice-powder, brushes, &c. The tray is supported by a stout wooden frame made of 3½-inch quartering, each part being united by morticing. A water-tap

must be fixed at a moderate distance from the tray, and a waste-pipe let into the bottom of the tray at one corner. To prevent overflow, it is a common practice to have a short iron waste-pipe screwed into the exit-pipe, so that when it is desired to run off the whole of the water, this can be readily done by simply unscrewing the waste-pipe.

As the flooring in front of the scouring tray invariably becomes very wet from the dripping of water from the articles after rinsing, it is a good plan to have a wooden platform for the workmen to stand upon. Four or five strips of inch boarding placed about 2 inches apart, and screwed to several pieces of 3-inch quartering, form a very serviceable platform.

224. Nickel-work that is to be left *dead*, that is, not polished, should be rinsed in clean boiling water, and allowed to dry by the heat it has acquired in the hot-water bath. No part of the surface should be touched by the fingers, as they invariably leave a stain, which is unsightly. Cast-iron work, when well nickel-plated, assumes a very beautiful dead white lustre, and should not be clumsily handled ere it leaves the plater's premises.

225. It will please many of our amateur readers and nickel-platers on a small scale to know that *rolled nickel anodes*, of moderate thickness, may now be obtained of any length, and up to one foot in width.

LIST OF ARTICLES REQUIRED IN ELECTRO-GILDING, PLATING, ETC.

Gilding battery-jar.
Plating battery-jar.
Gilding bath, of glass or stone-ware.
Plating bath, of wood or stone-ware.
Gold anode rolled out to a moderate thickness.
Silver anode rolled out to a moderate thickness.
1 lb. of stout copper wire.
1 lb. of thin copper wire for slinging.
One or two Bath bricks, to be rubbed together until powdered, or
A few pounds of powdered pumice-stone.
Several brushes, consisting of 1, 2, 3, and 4 rows each.
Several sheets of emery-cloth, Nos. 1, 2, and 3.
Several lumps of pumice-stone.
A Water-of-Ayr stone about three-quarters of an inch square.
Pair of flat pliers.
Several files.
Chamois leather.
1 ounce of rouge.
½ lb. of mercury.
Several binding-screws.
A few sheets of filtering-paper.
1 quart of box-sawdust.
Several scratch-brushes, which, for economy's sake, may be cut in half, and the ends soldered.
Scratch-brush lathe, and "chuck."
Evaporating dish to hold half a pint.
Rotten stone, 1 lb.
Borax, 1 ounce.
Silver solder.
Soft solder.
Blowpipe.
Rosin.
Soldering iron.
Cyanide of potassium for silver bath.
Cyanide of potassium for gilding bath.
Nitric acid.
Hydrochloric acid.

Sulphuric acid.
Sulphate of copper for electrotyping.
Burnishers.
Nitrate of mercury (made by dissolving mercury in nitric acid).
One or two "buffs" for polishing.
Charcoal, several pieces.
One or two glass measures.
Nitrate of potash for stripping solution.
Fuming nitric acid.
Acetic acid.
Sal ammoniac.
Scales and weights—small and large.
Sheet copper for gilding battery.
Sheet copper for plating battery.
Stout sheet zinc for plating battery.
Stout sheet zinc or cast-zinc bar for gilding battery.
Porous cells.
Carbonate of potassa.
Fine silver for solutions.
Fine gold for solutions.
A few gallons of distilled or rain-water.
Bisulphide of carbon for "bright" plating.
Common salt.
Caustic soda (see p. 48).
Silver sand.
Jar for stripping solution (see p. 56).
Plumbago and a camel-hair pencil.
A tub or other vessel for cleaning work.
Several pans or rinsing vessels.
Brass rods to suspend articles to be plated.

LIST OF REQUIREMENTS FOR NICKEL-PLATING UPON A MODERATE SCALE.

A 60-gallon wooden tank lined with lead and match-boarding.
50 lbs. crystals of double sulphate of nickel and ammonia.
12 nickel anodes (rolled nickel) about 12 inches by 6.
12 copper hooks for suspending anodes.
4 three-gallon Bunsen (carbon and zinc) batteries.
3 brass rods (two for anodes and one for suspending articles).
10-gallon iron tank for hot potash solution.
Copper wire for slinging work.
Two and four-rowed scouring brushes.
Hydrometer for determining the specific gravity of the bath.

Test papers.
3-gallon stone pan for cyanide dip.
Ditto for hydrochloric acid dip.
Binding screws, or clamps, for connection.
Stout copper wire for battery-conducting wires.
Powdered pumice.

THERMOMETER SCALES.

French, or Centigrade.			English, or Fahrenheit.
0°	Cent. or C. ..	*equals* ..	32 Fahr. or F.
5	,, ..	,, ..	41 ,,
10	,, ..	,, ..	50 ,,
15	,, ..	,, ..	59 ,,
20	,, ..	,, ..	68 ,,
25	,, ..	,, ..	77 ,,
30	,, ..	,, ..	86 ,,
35	,, ..	,, ..	95 ,,
40	,, ..	,, ..	104 ,,
45	,, ..	,, ..	113 ,,
50	,, ..	,, ..	122 ,,
55	,, ..	,, ..	131 ,,
60	,, ..	,, ..	140 ,,
65	,, ..	,, ..	149 ,,
70	,, ..	,, ..	158 ,,
75	,, ..	,, ..	167 ,,
80	,, ..	,, ..	176 ,,
85	,, ..	,, ..	185 ,,
90	,, ..	,, ..	194 ,,
95	,, ..	,, ..	203 ,,
100	,, ..	,, ..	212 ,,
200	,, ..	,, ..	392 ,,
300	,, ..	,, ..	572 ,,
356	(mercury boils)	,, ..	662 (mercury boils).

TABLE OF WEIGHTS AND MEASURES.

APOTHECARIES' WEIGHT.

1 Pound	*equals*	12 ounces.
1 Ounce	,,	8 drachms (480 grains*).
1 Drachm	,,	3 scruples.
1 Scruple	,,	20 grains.

TROY WEIGHT.

1 Pound	*equals*	12 ounces.
1 Ounce	,,	20 pennyweights (dwts.) (480 grains*).
1 Pennyweight	,,	24 grains.

IMPERIAL MEASURE.

1 Gallon	*equals*	8 pints.
1 Pint	,,	20 ounces.
1 Ounce	,,	8 drachms.
1 Drachm	,,	60 minims.

FRENCH MEASURES OF WEIGHT.

		English grains.
Milligramme	*equals*	·0154
Centigramme	,,	·1543
Décigramme	,,	1·5434
Gramme	,,	15·4340

MEASURE OF VOLUME.

1 litre *equals* about 34 English fluid ounces.

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* An ounce Avoirdupois is only 437·5 grains.

INDEX.

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